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Dedig et al.

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(45) **Date of Patent:** **Apr. 27, 2004**

(54) **INJECTOR SYSTEMS AND SYRINGE ADAPTERS FOR USE THEREWITH**

FOREIGN PATENT DOCUMENTS

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(73) Assignee: **Medrad, Inc.**, Indianola, PA (US)

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 220 days.

Drawings of Dual Flange Injector Head (publicly disclosed in Jul. of 1995).

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(21) Appl. No.: **09/633,299**

(List continued on next page.)

(22) Filed: **Aug. 8, 2000**

Related U.S. Application Data

Primary Examiner—Manuel Mendez

Assistant Examiner—Kevin C. Sirmons

(63) Continuation-in-part of application No. 09/365,285, filed on Jul. 30, 1999.

(74) *Attorney, Agent, or Firm*—Groegory L. Bradley; Henry E. Bartony

(51) **Int. Cl.**⁷ **A61M 1/00**

(57) **ABSTRACT**

(52) **U.S. Cl.** **604/152; 604/131**

An adapter includes a syringe carrier adapted to seat at least a portion of the syringe. The syringe carrier includes at least one rearward facing abutment member to abut at least one forward facing surface on a syringe. The syringe carrier includes an opening therein to allow a drive member of an injector to communicate forward force to the plunger through abutment without connective engagement between the drive member and the plunger. The adapter further includes a releasable mounting mechanism positioned to the rear of the syringe carrier to mount the adapter in a desired position relative to the front wall of the injector. An adapter includes a first section and a second section that are rotatable relative to each other about a hinge axis generally perpendicular to a longitudinal axis of the adapter. An adapter includes a first section and a second section that are generally the same in construction, the first section and the section being connectable to form a syringe carrier to seat at least a portion of the syringe.

(58) **Field of Search** 604/151-154, 604/67, 65, 131, 118, 189

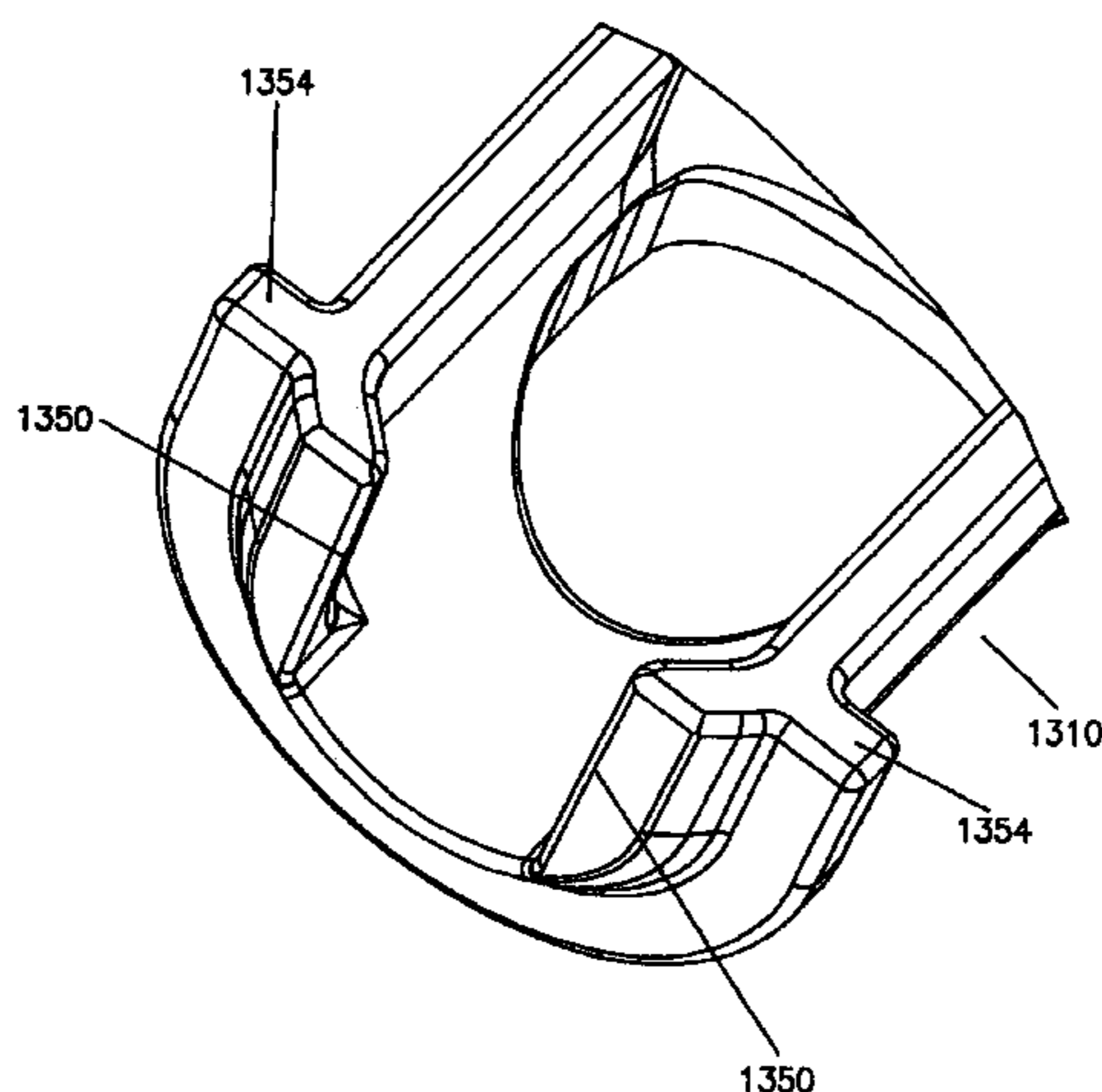
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35 Claims, 43 Drawing Sheets



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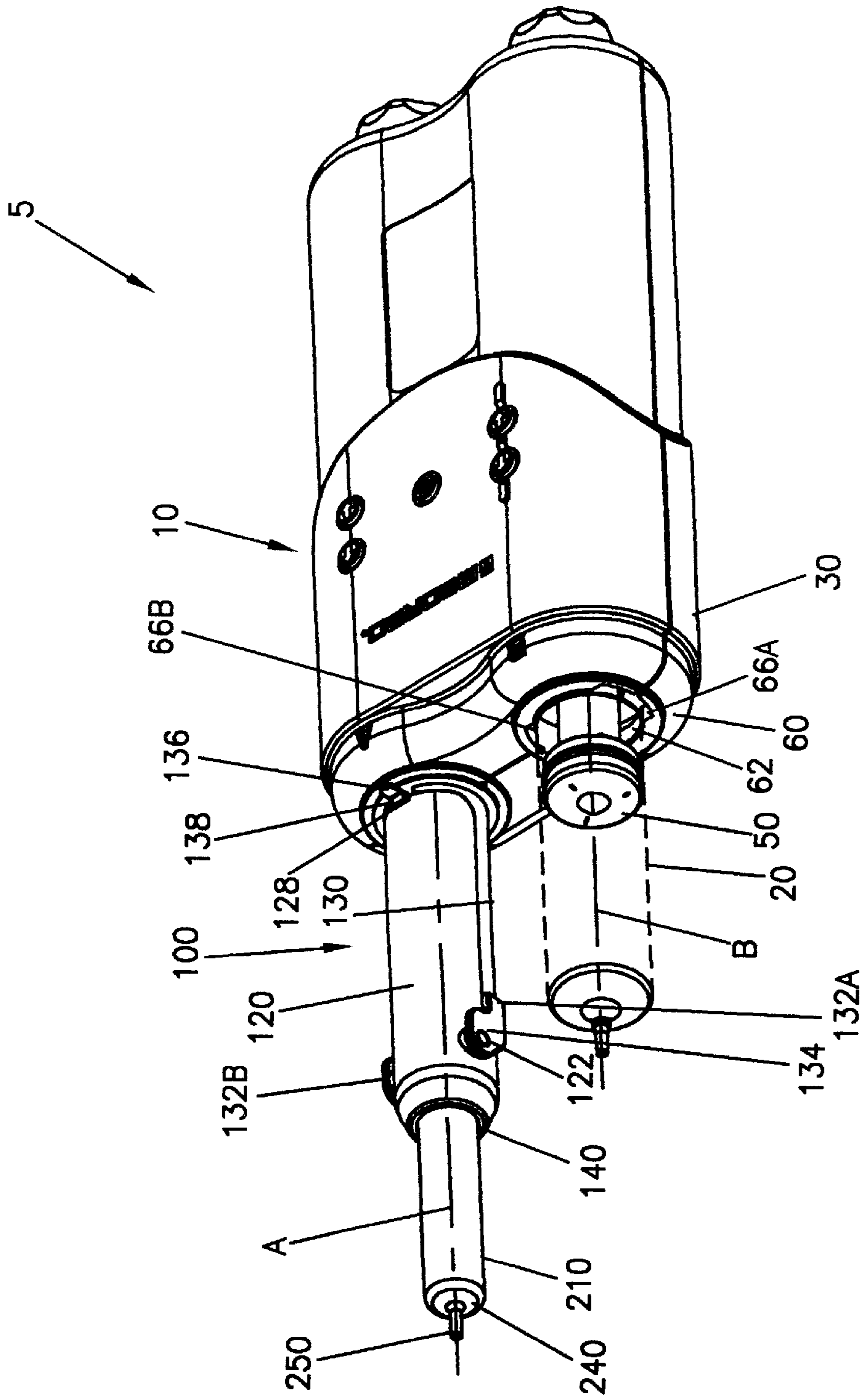


FIG. 1A

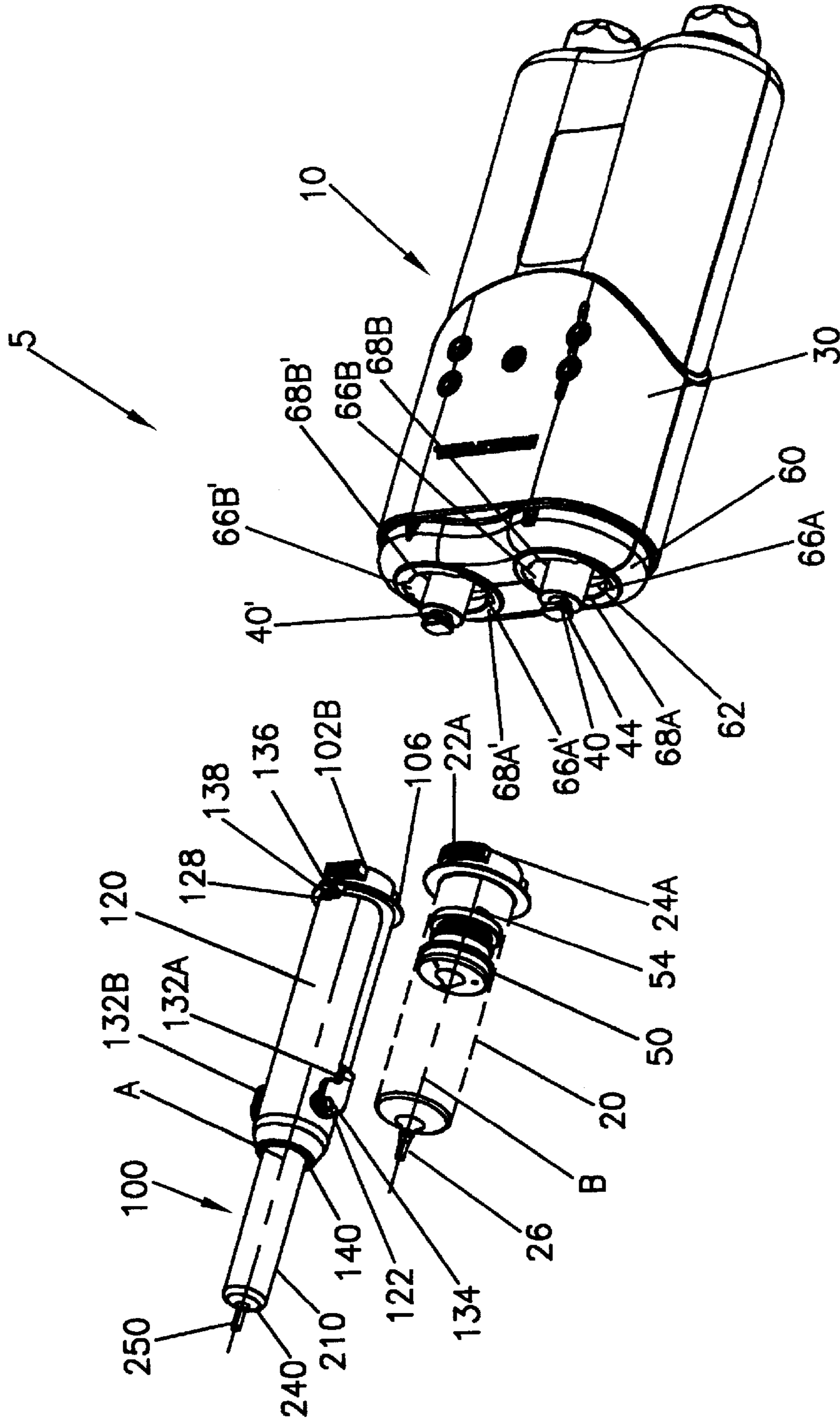


FIG. 1B

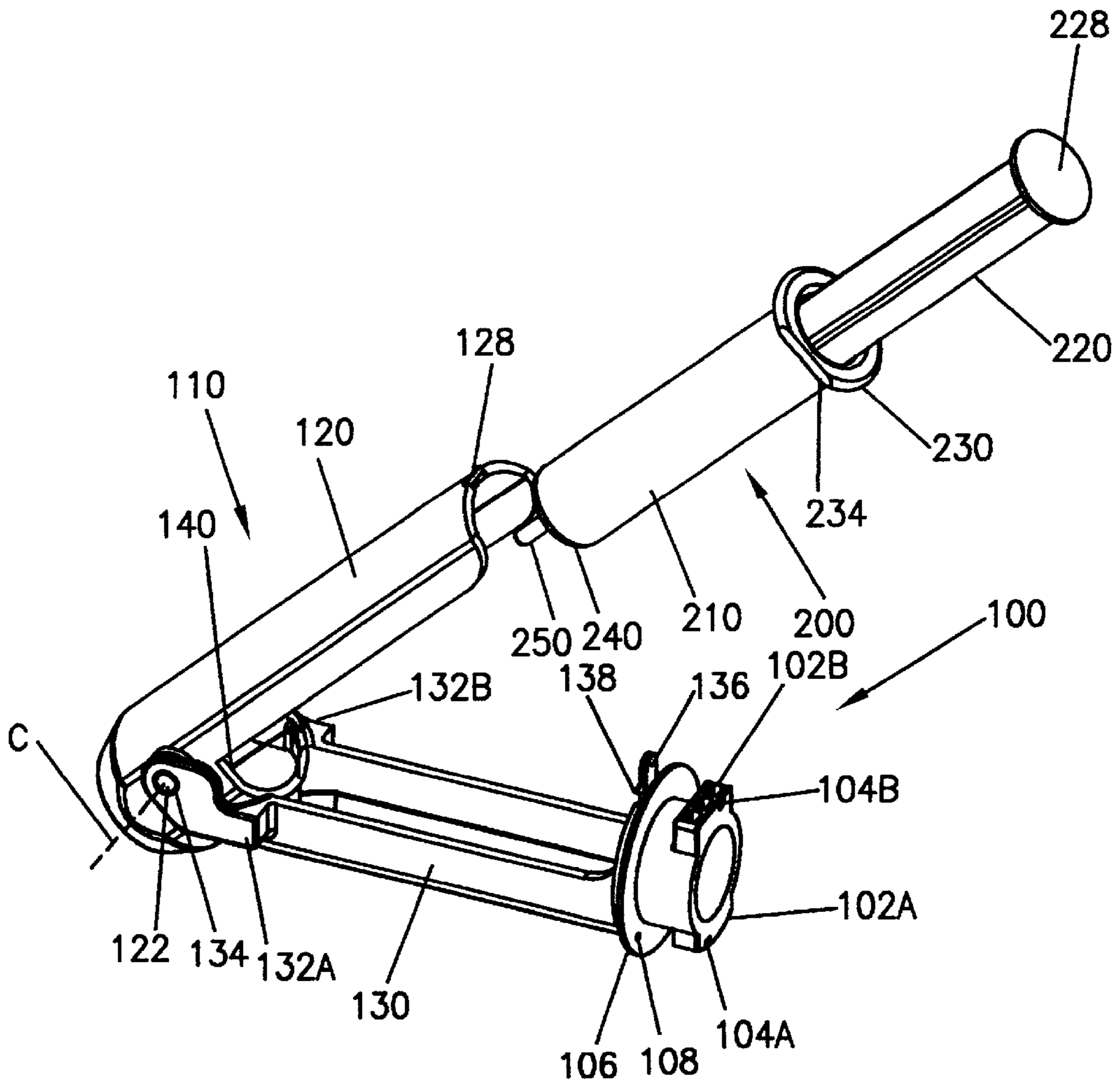


FIG. 2A

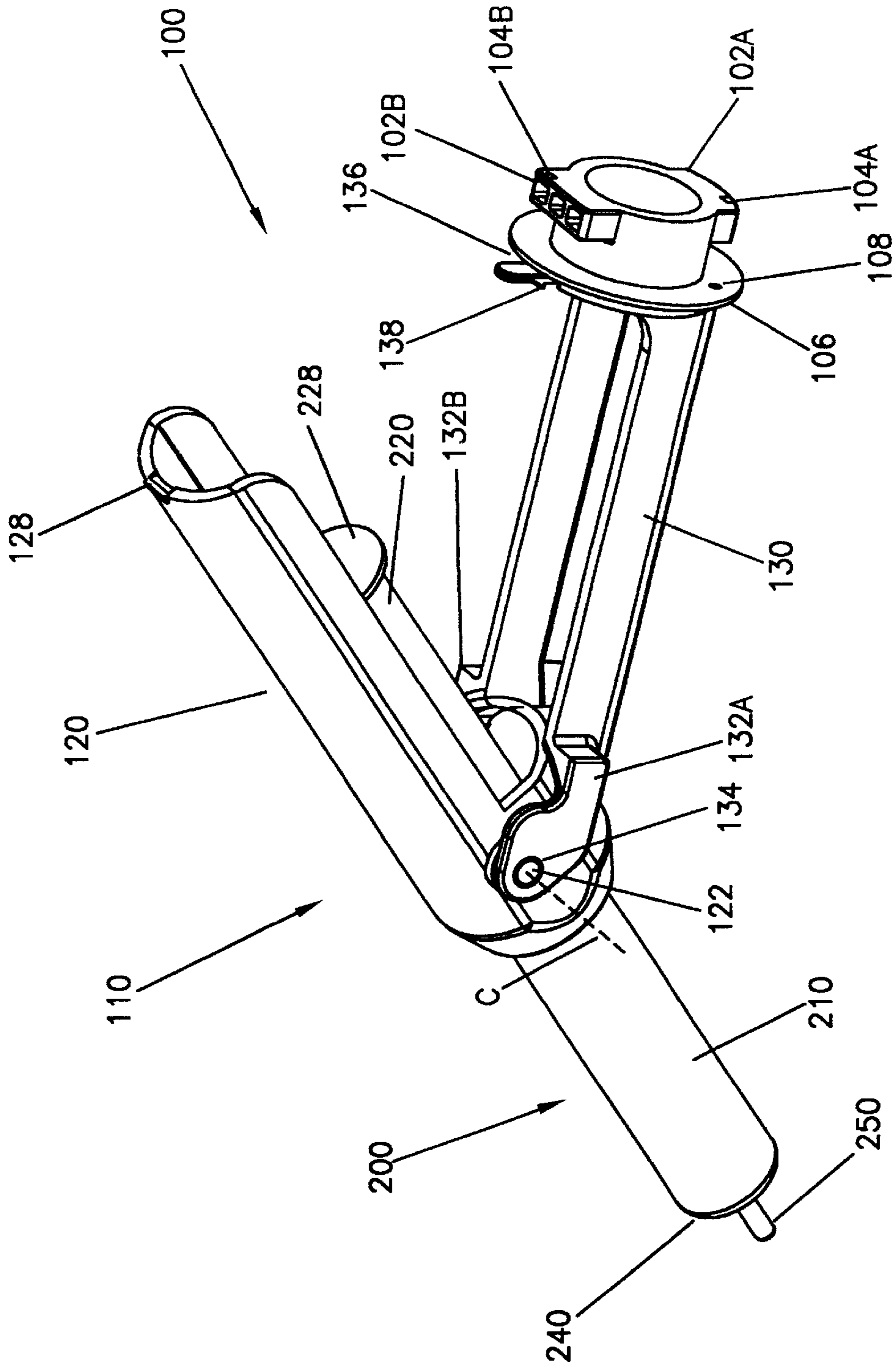


FIG. 2B

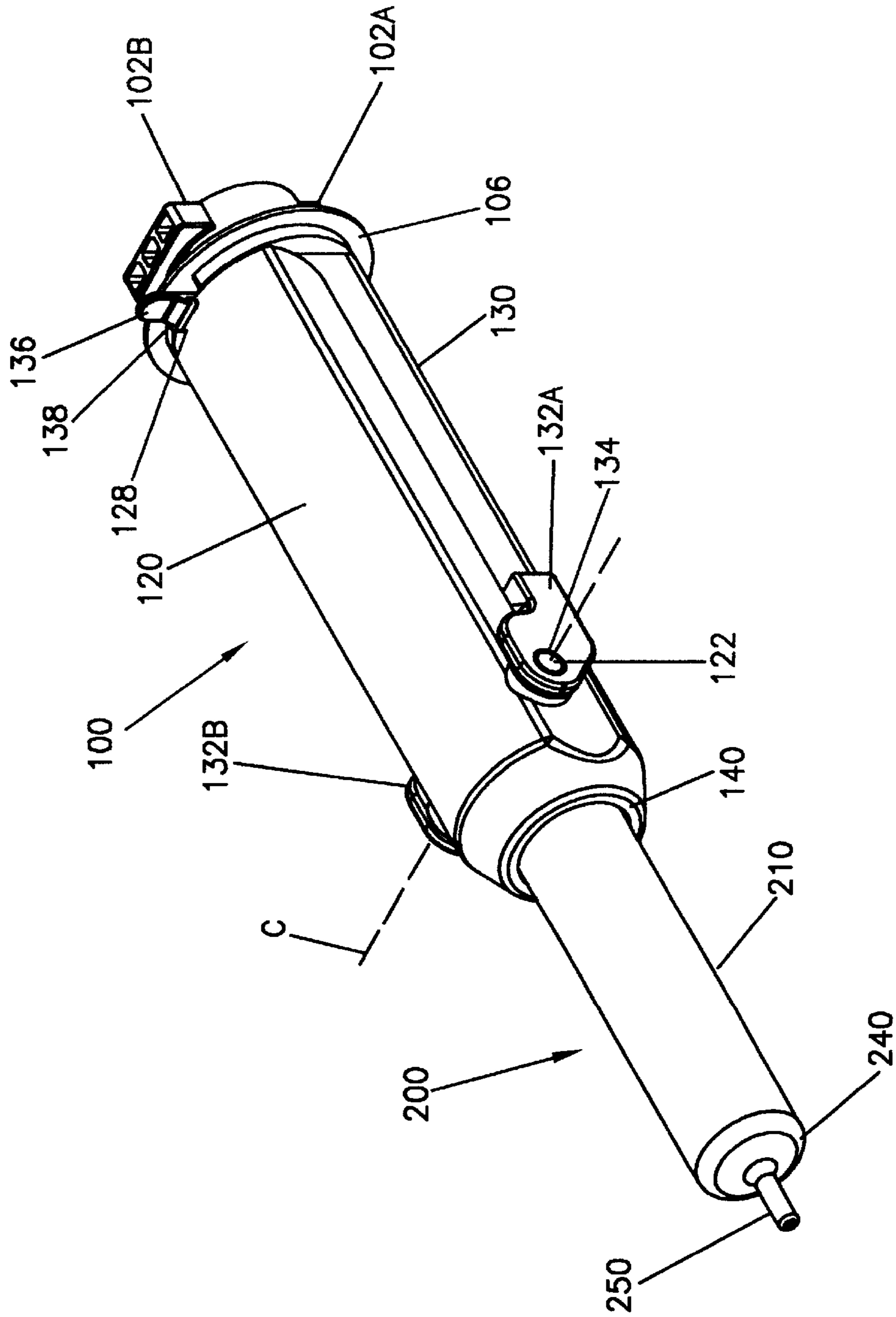


FIG. 2C

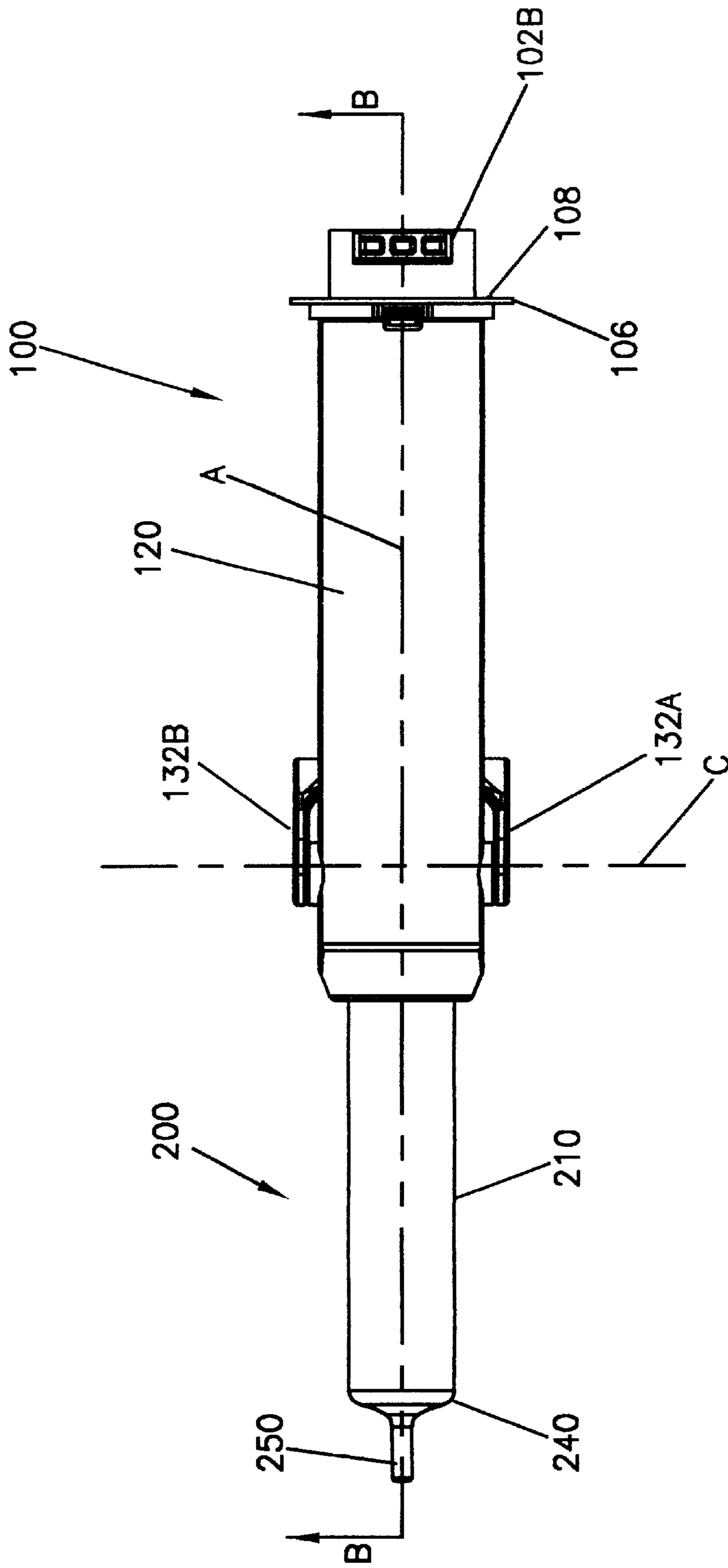


FIG. 2D

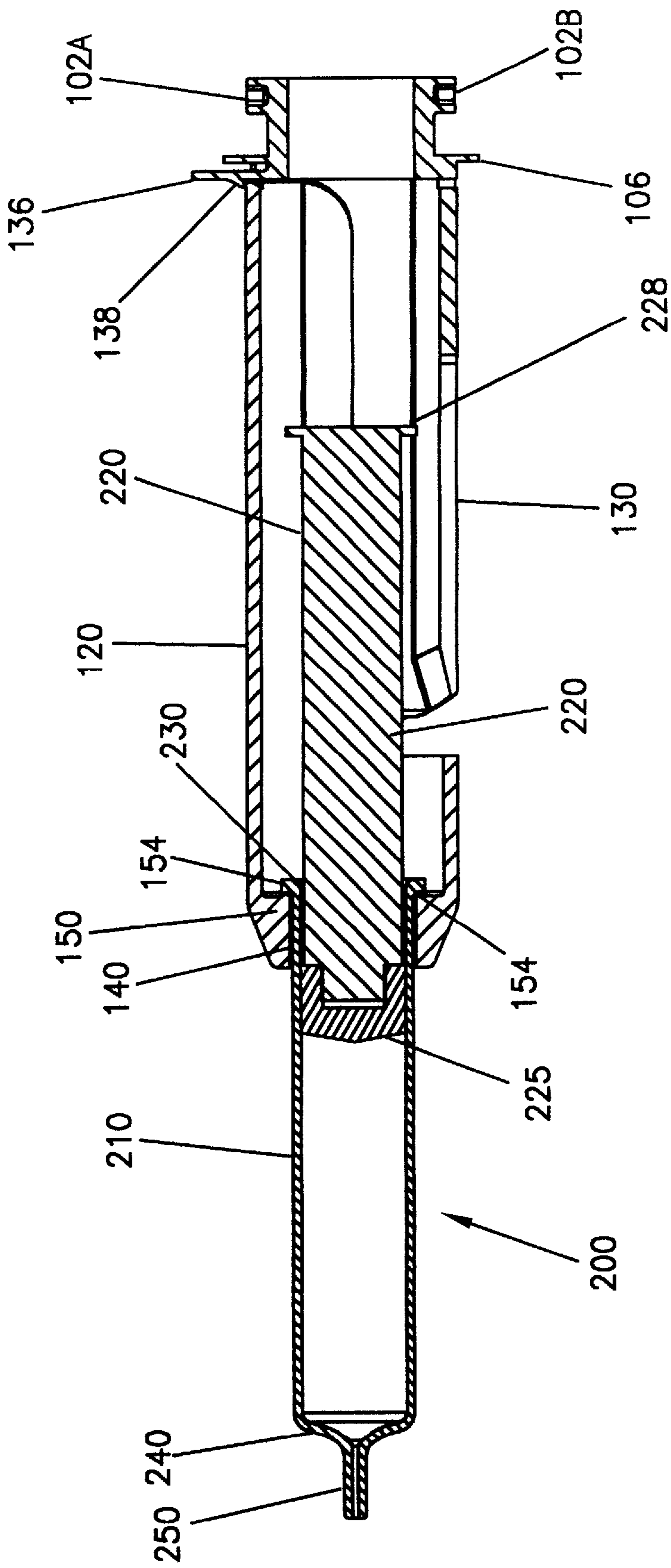


FIG. 2E

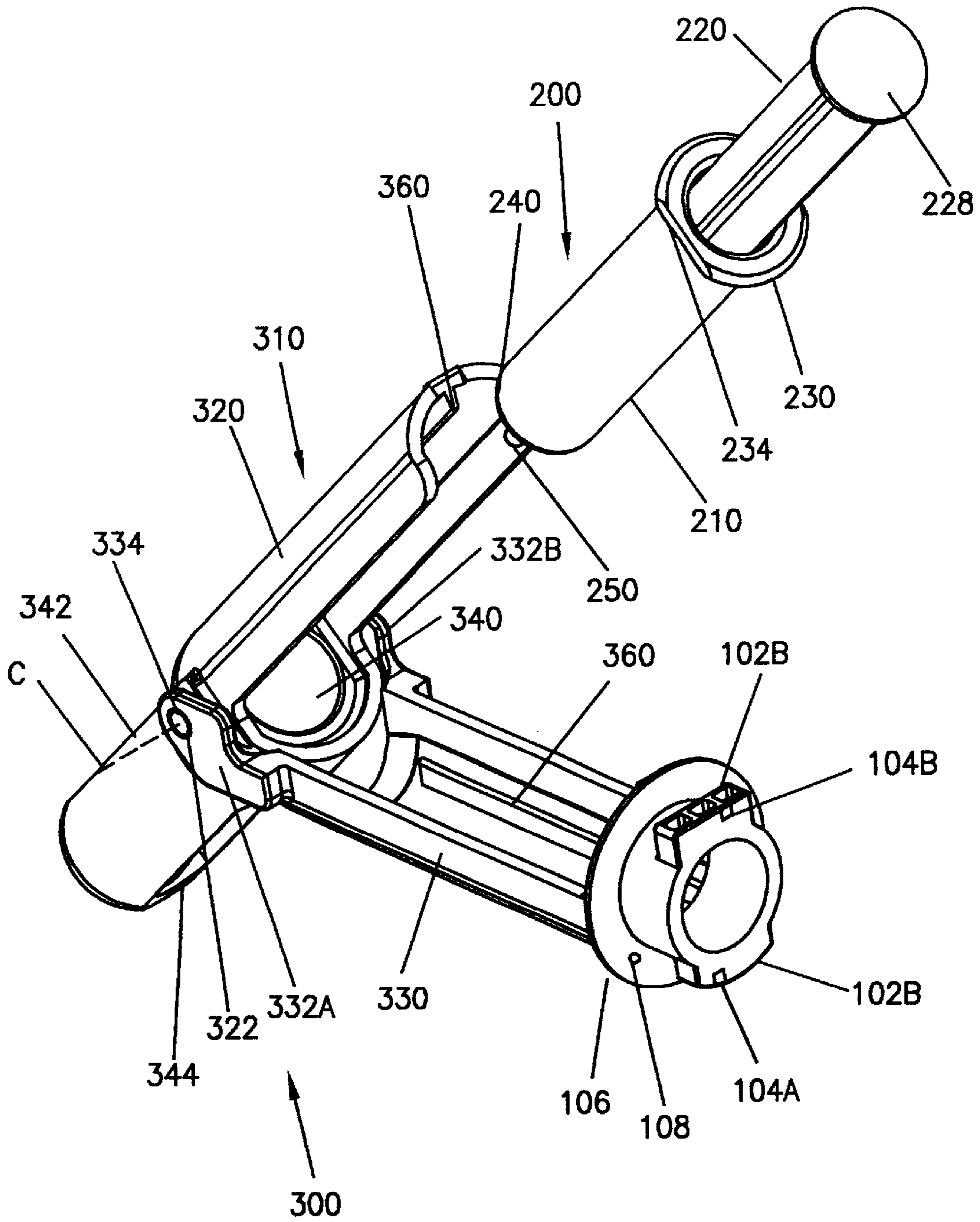


FIG. 3A

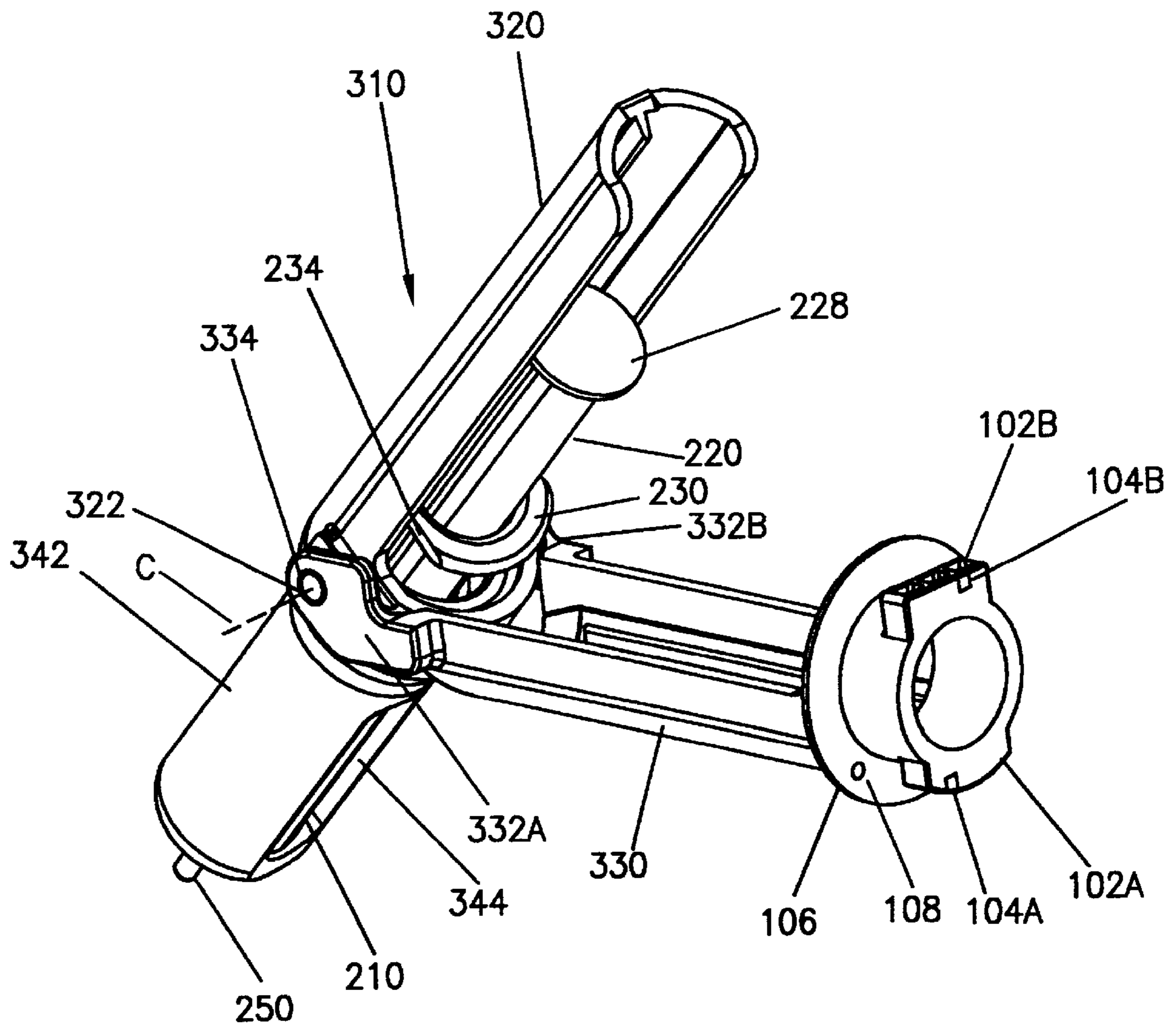


FIG. 3B

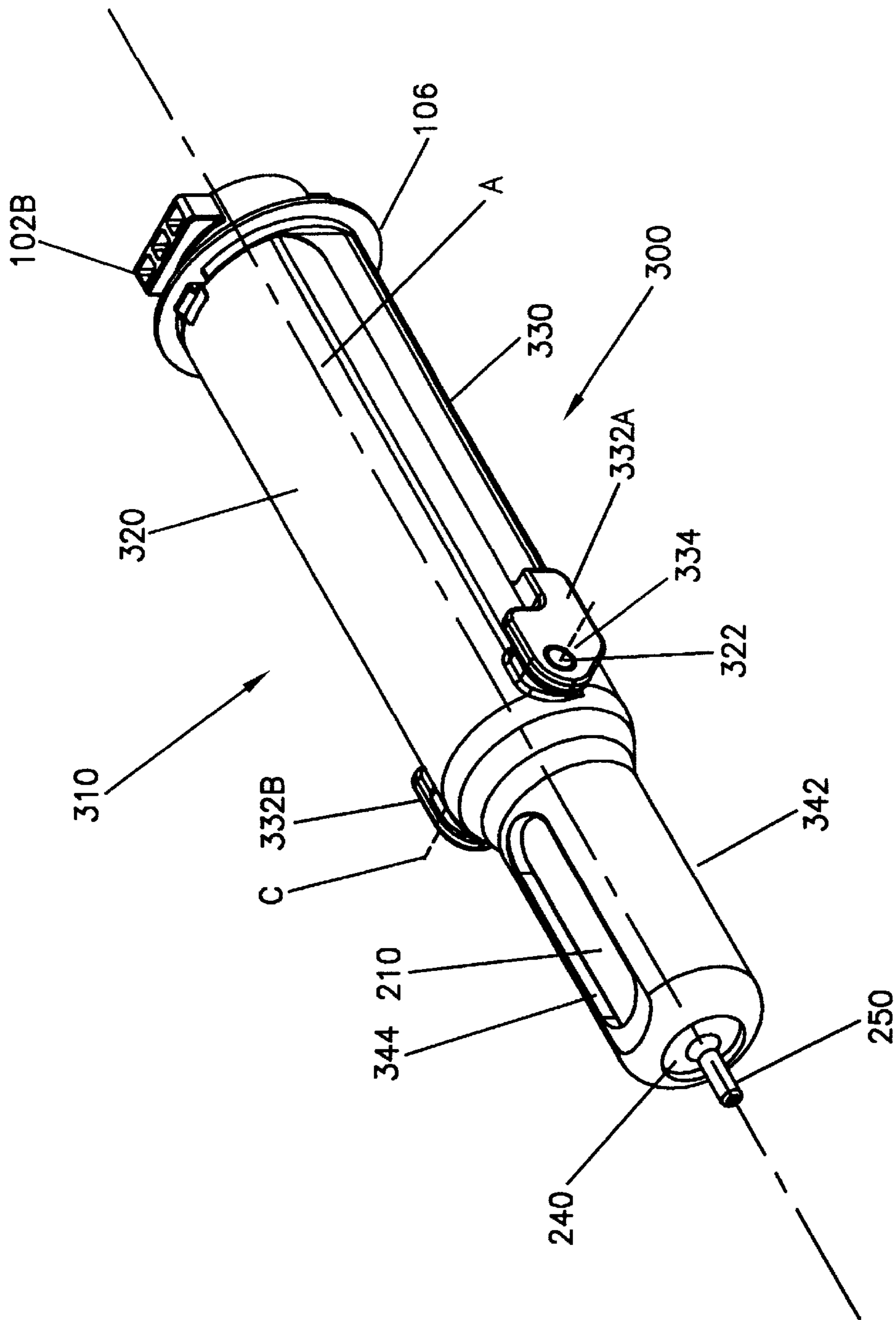


FIG. 3C

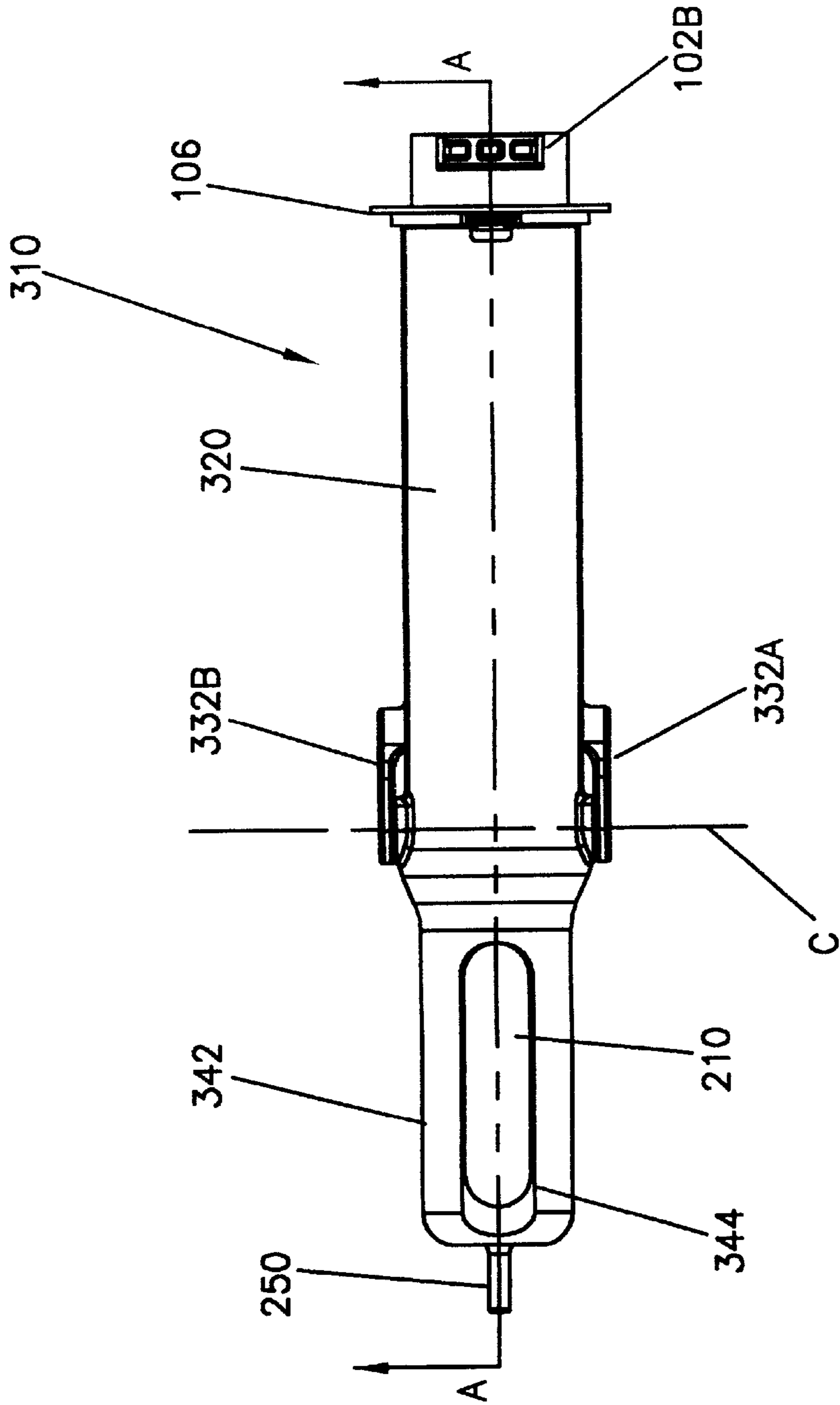
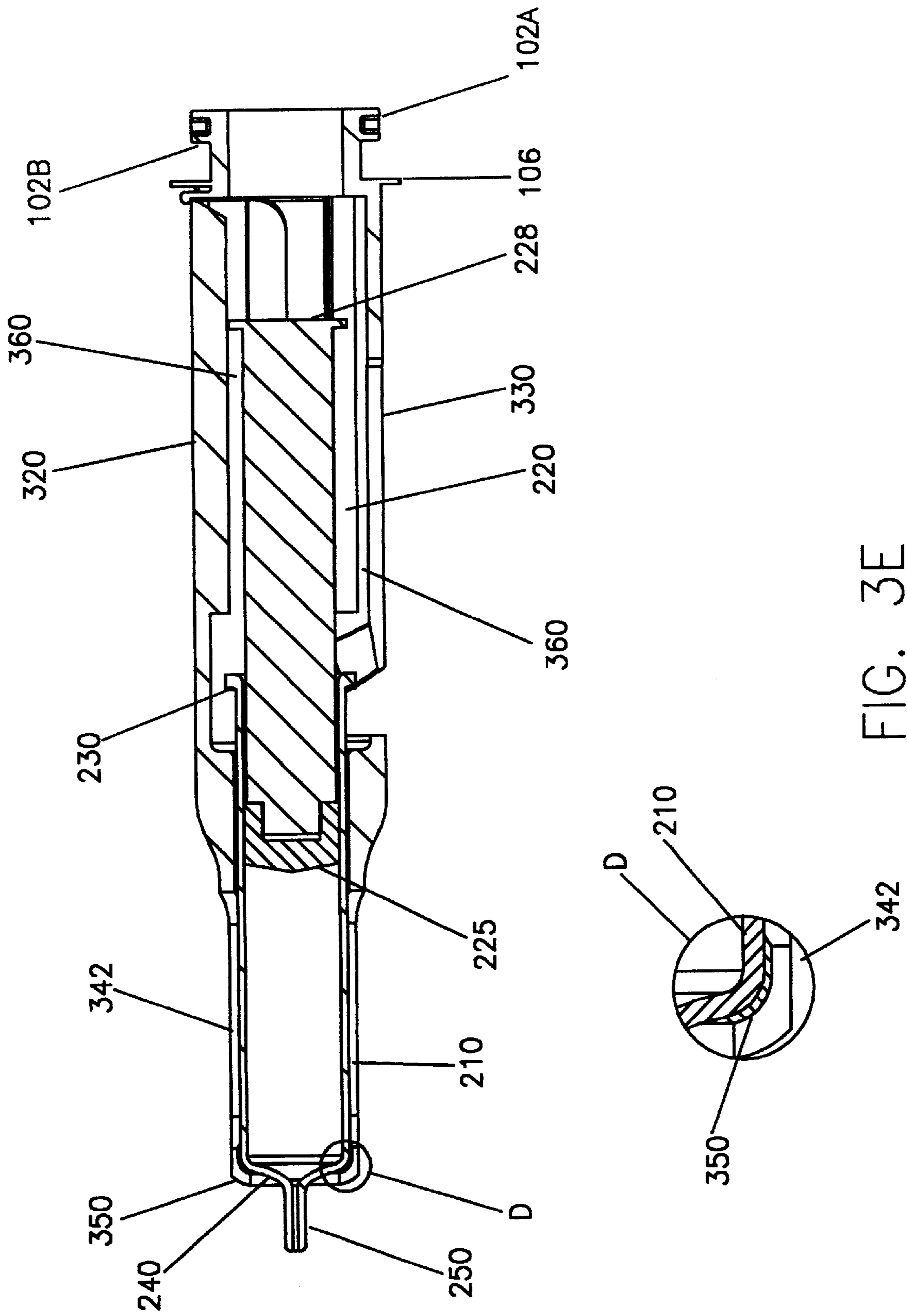


FIG. 3D



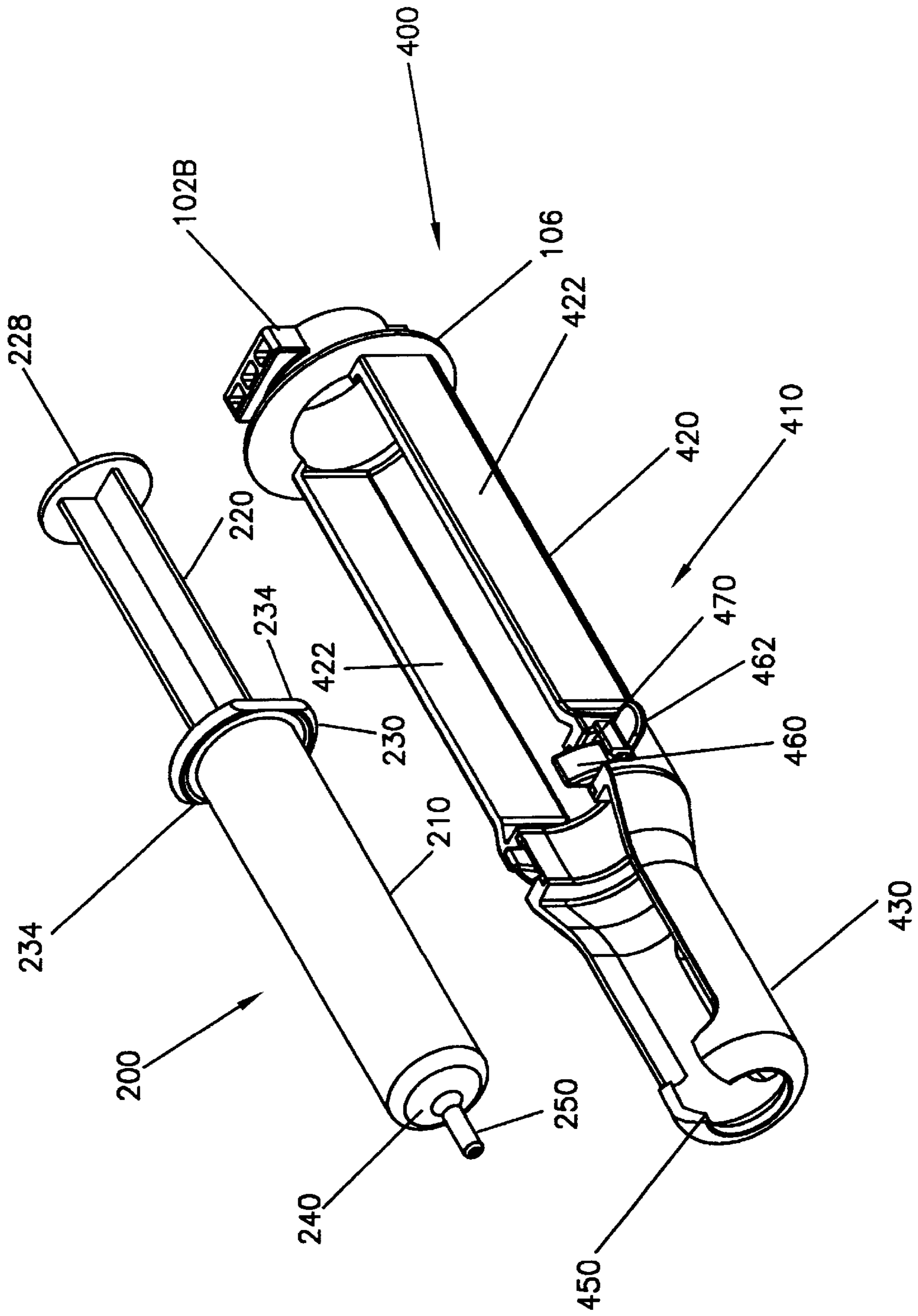


FIG. 4A

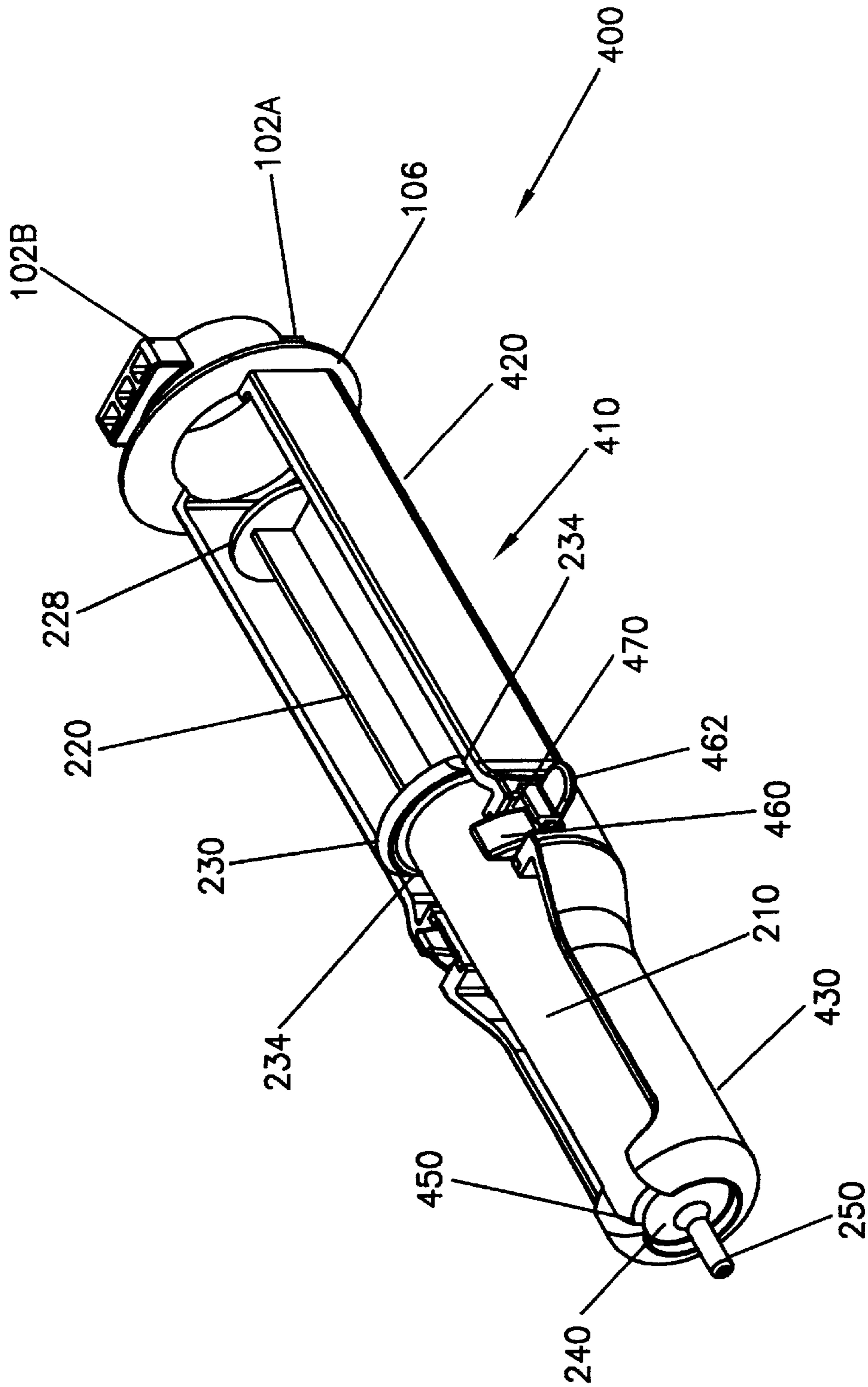


FIG. 4B

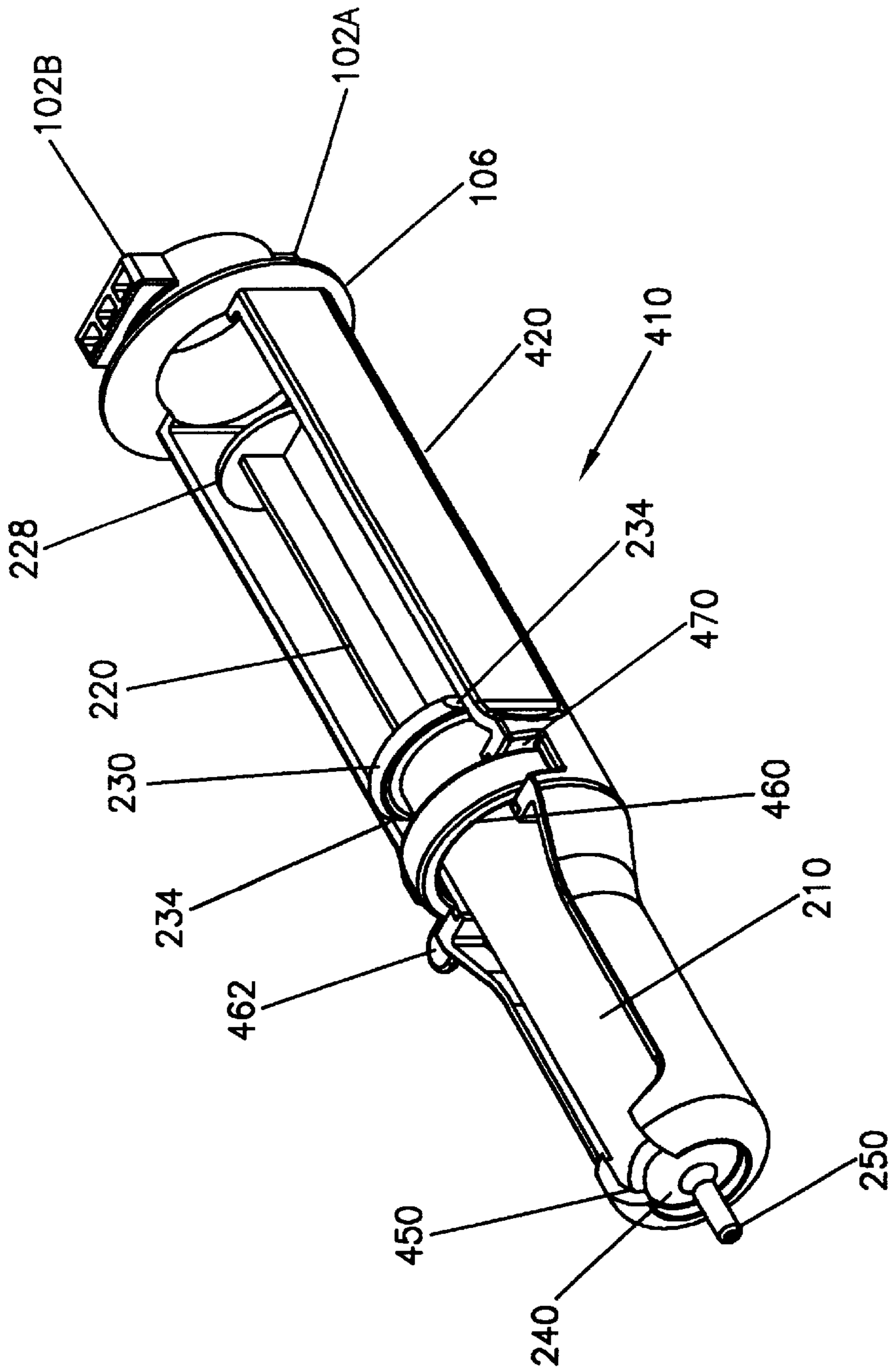


FIG. 4C

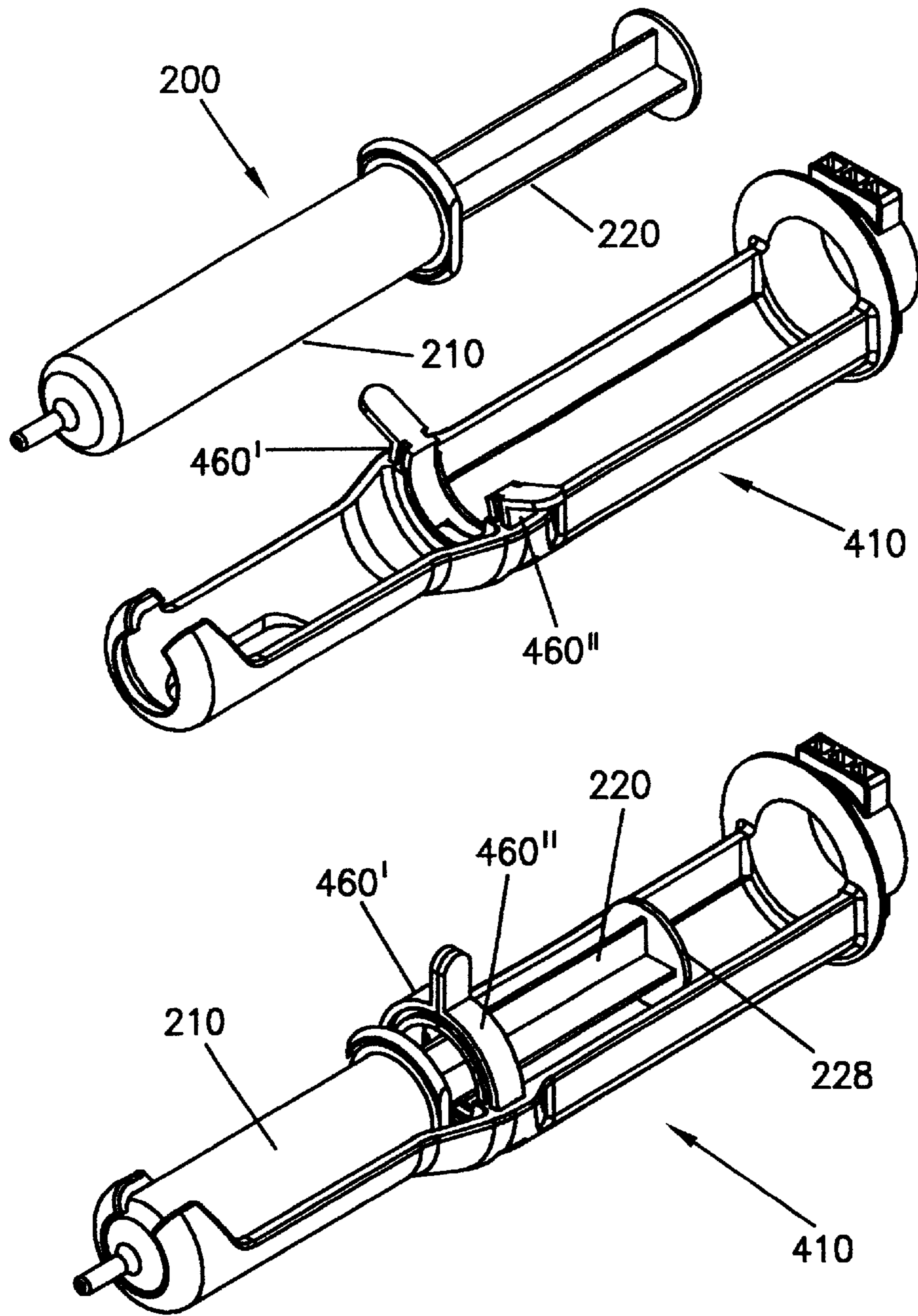


FIG. 4D

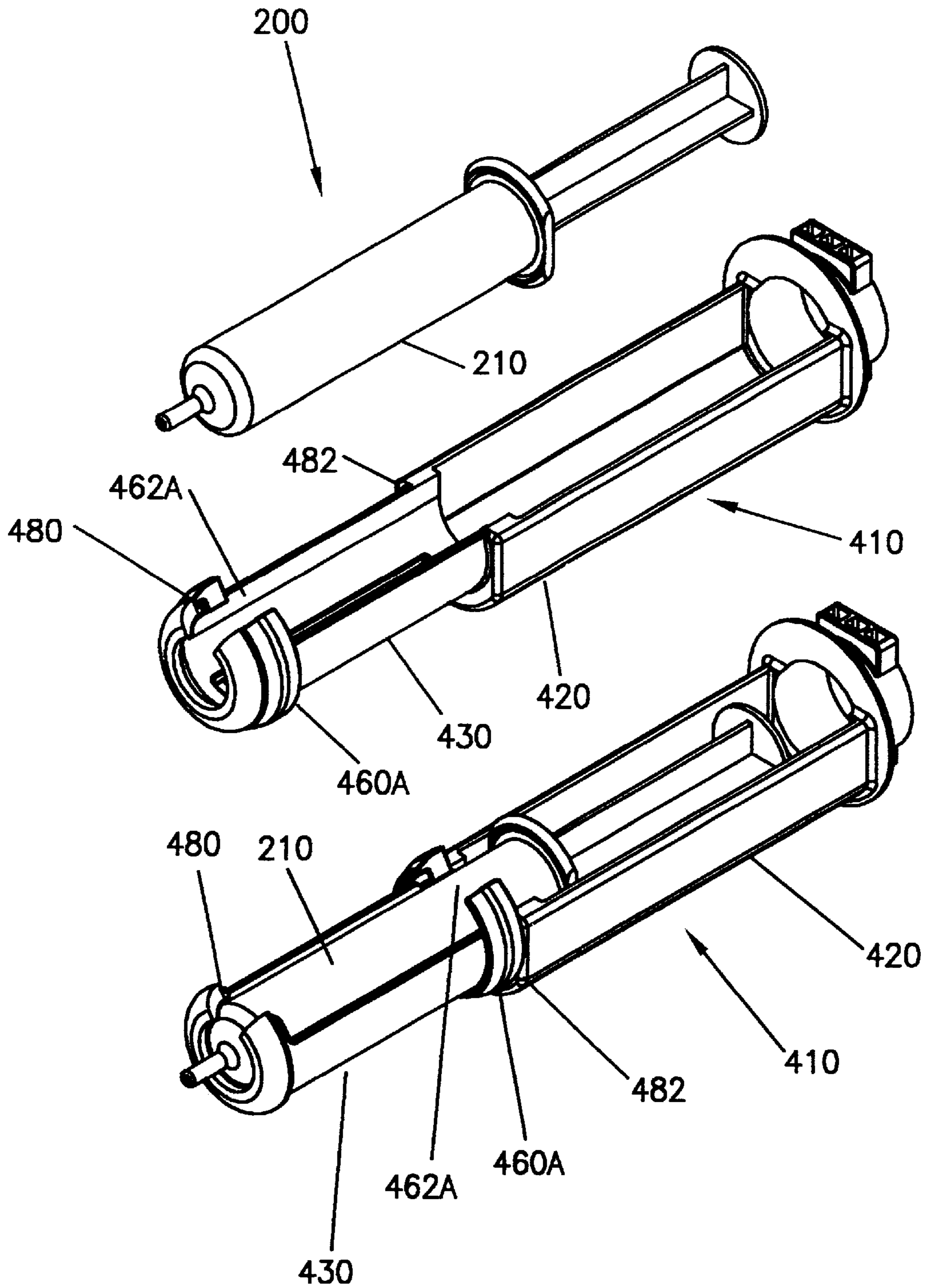


FIG. 4E

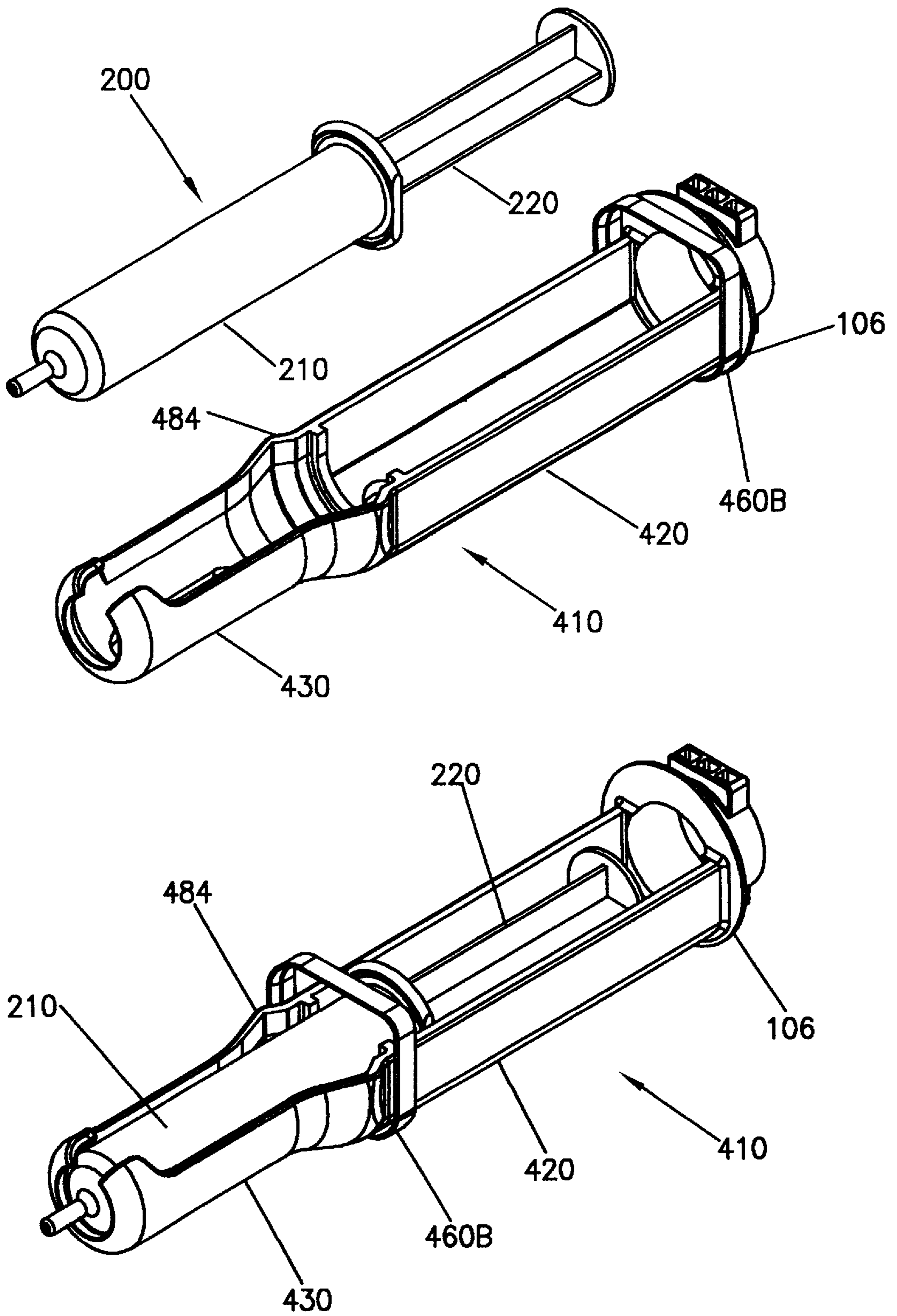


FIG. 4F

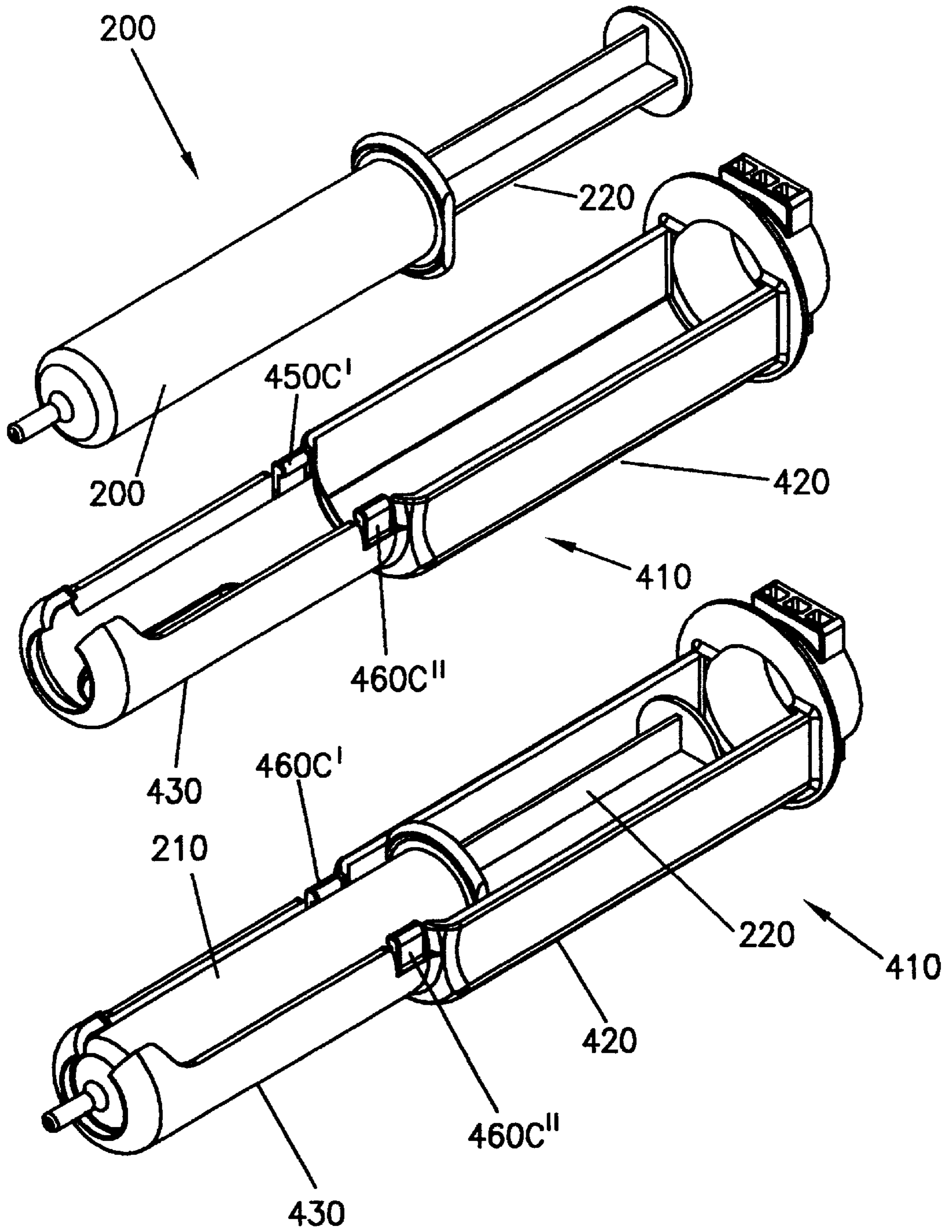


FIG. 4G

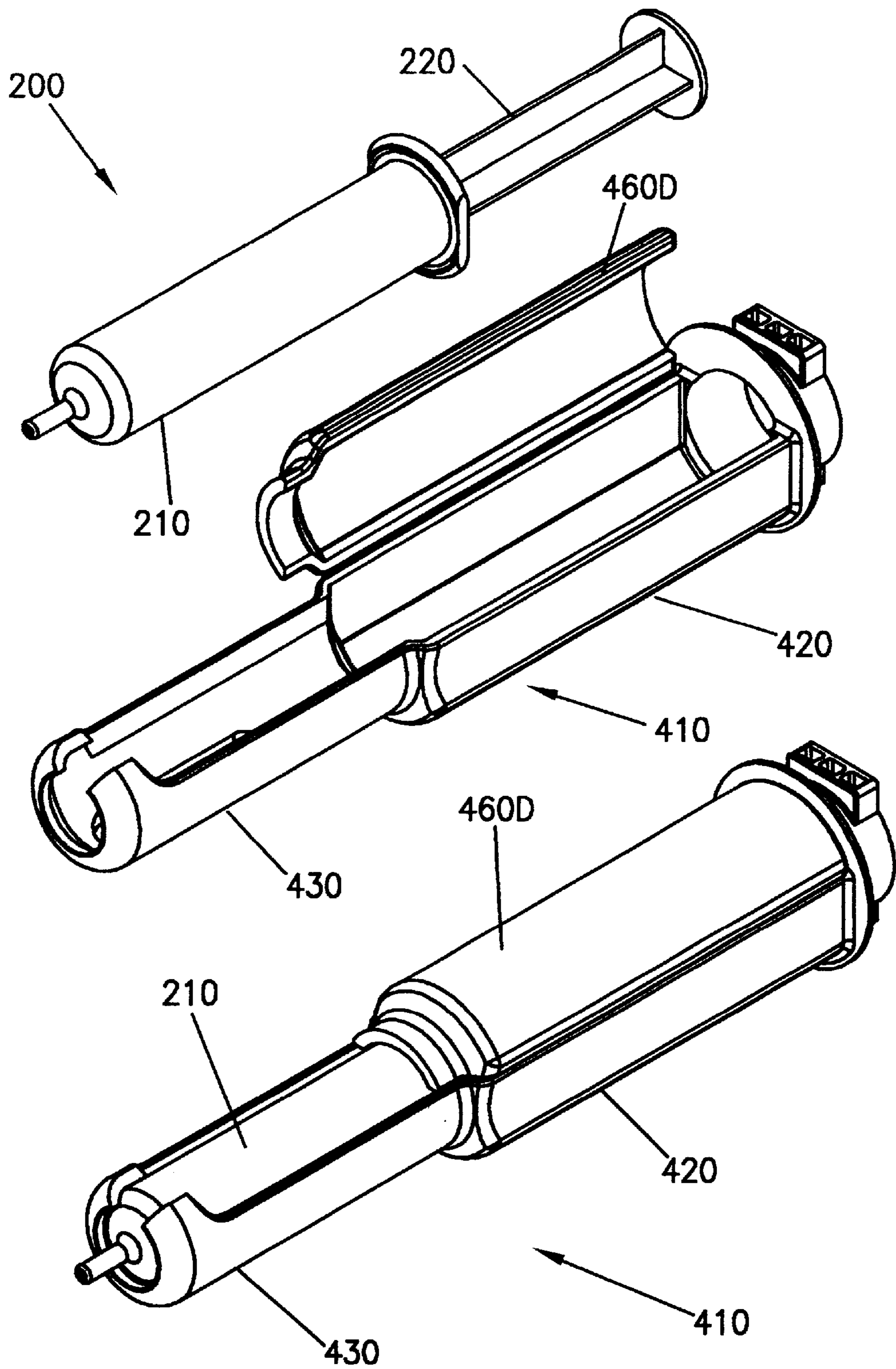


FIG. 4H

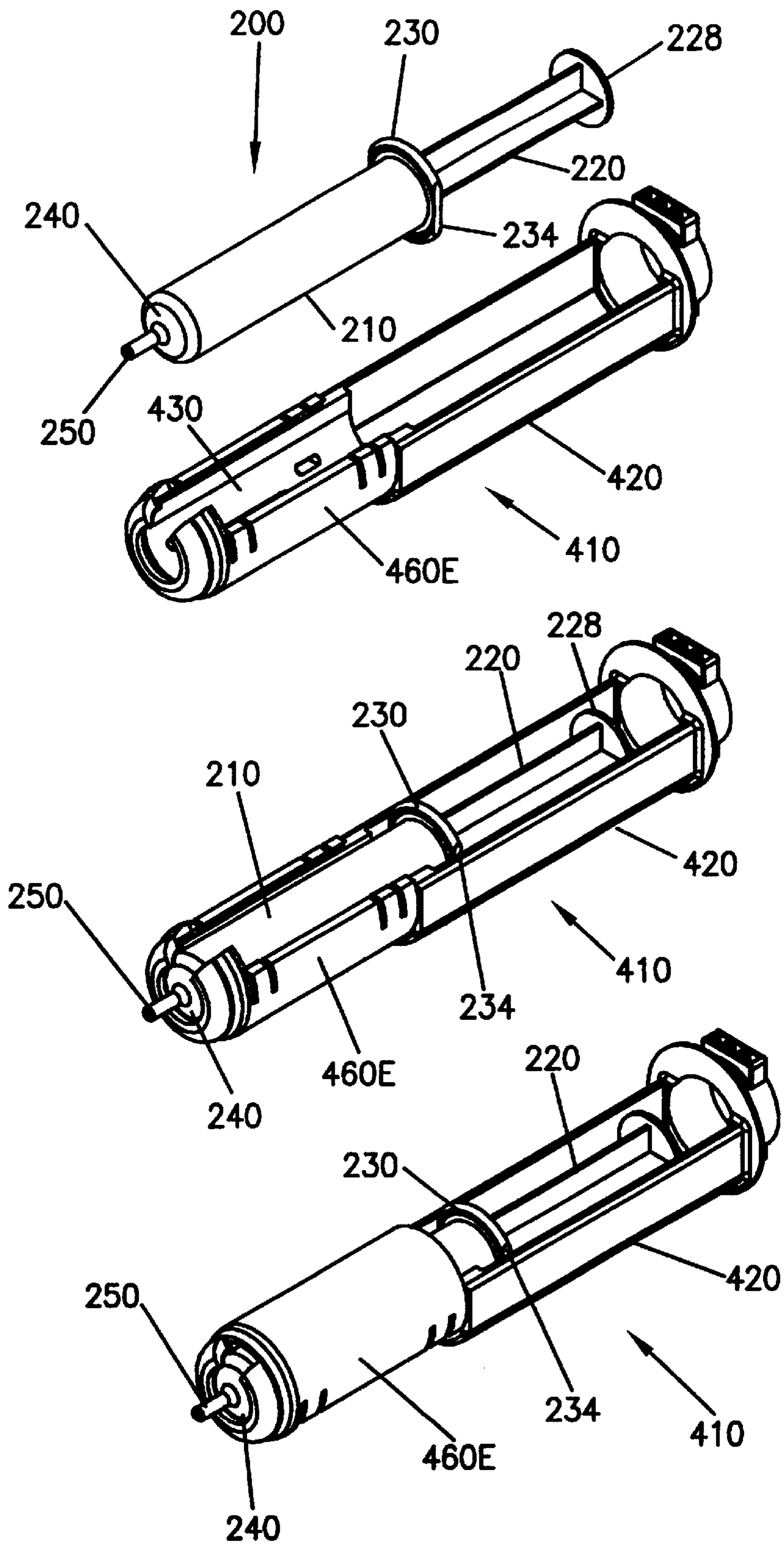


FIG. 4I

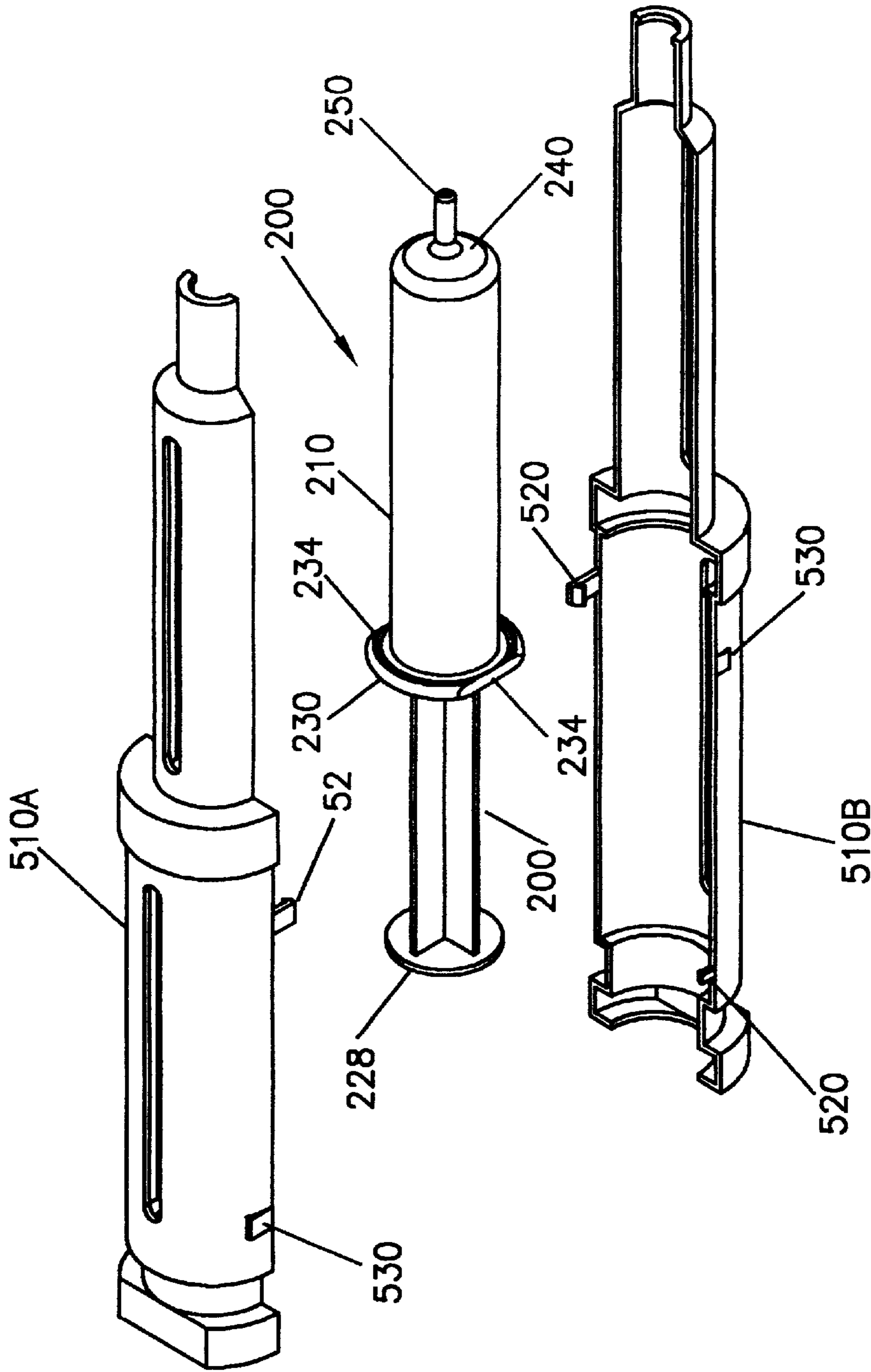


FIG. 5A

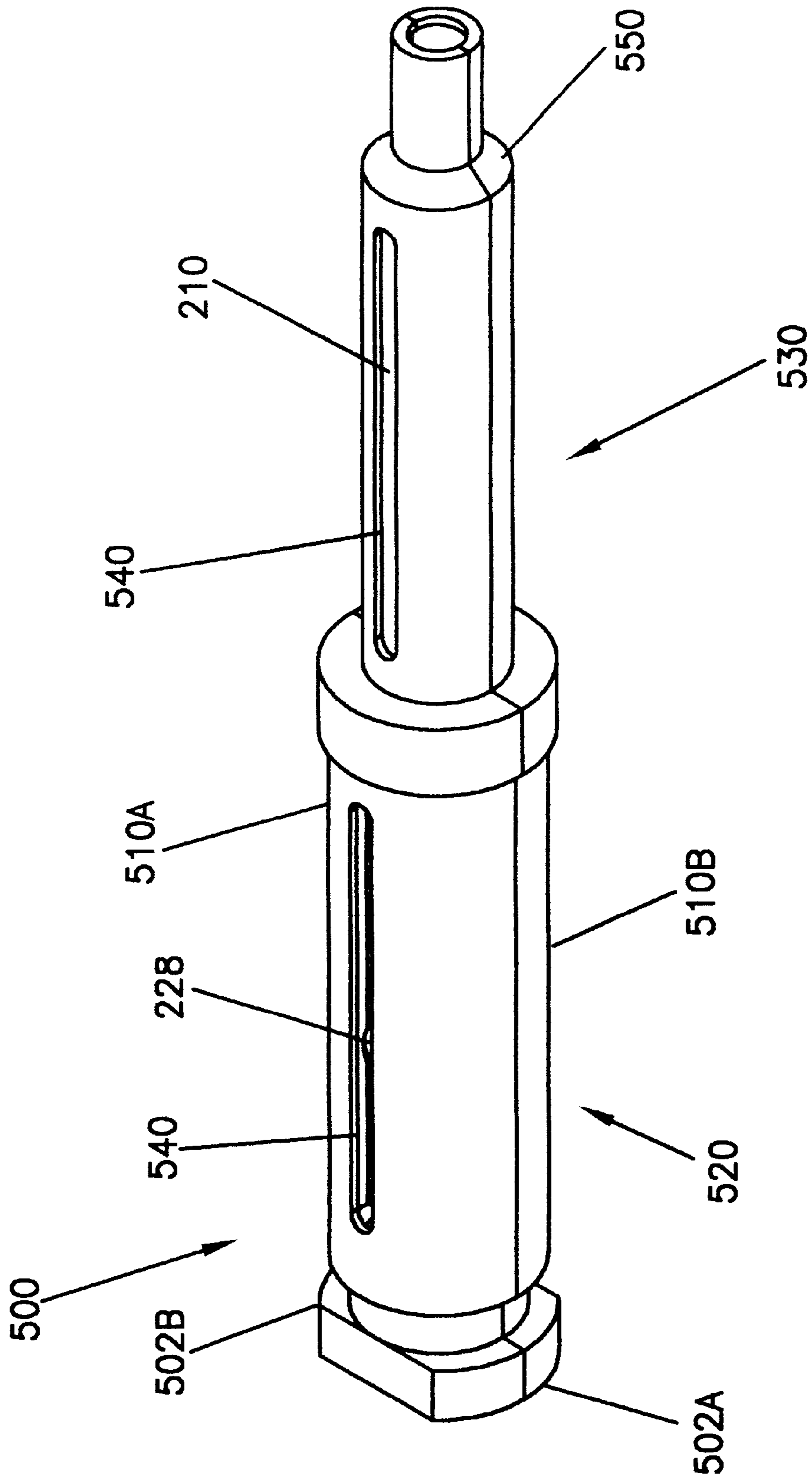


FIG. 5B

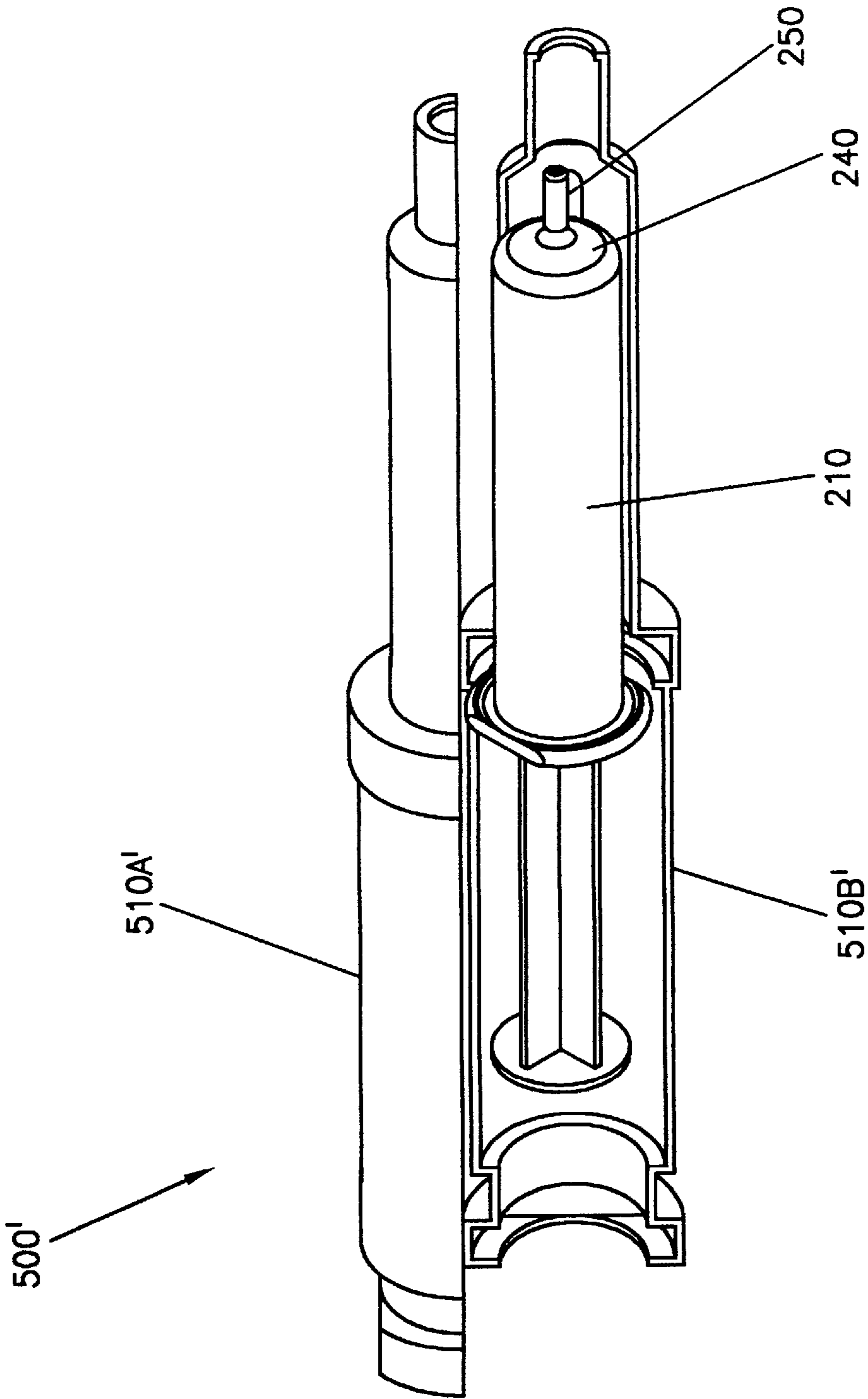


FIG. 6A

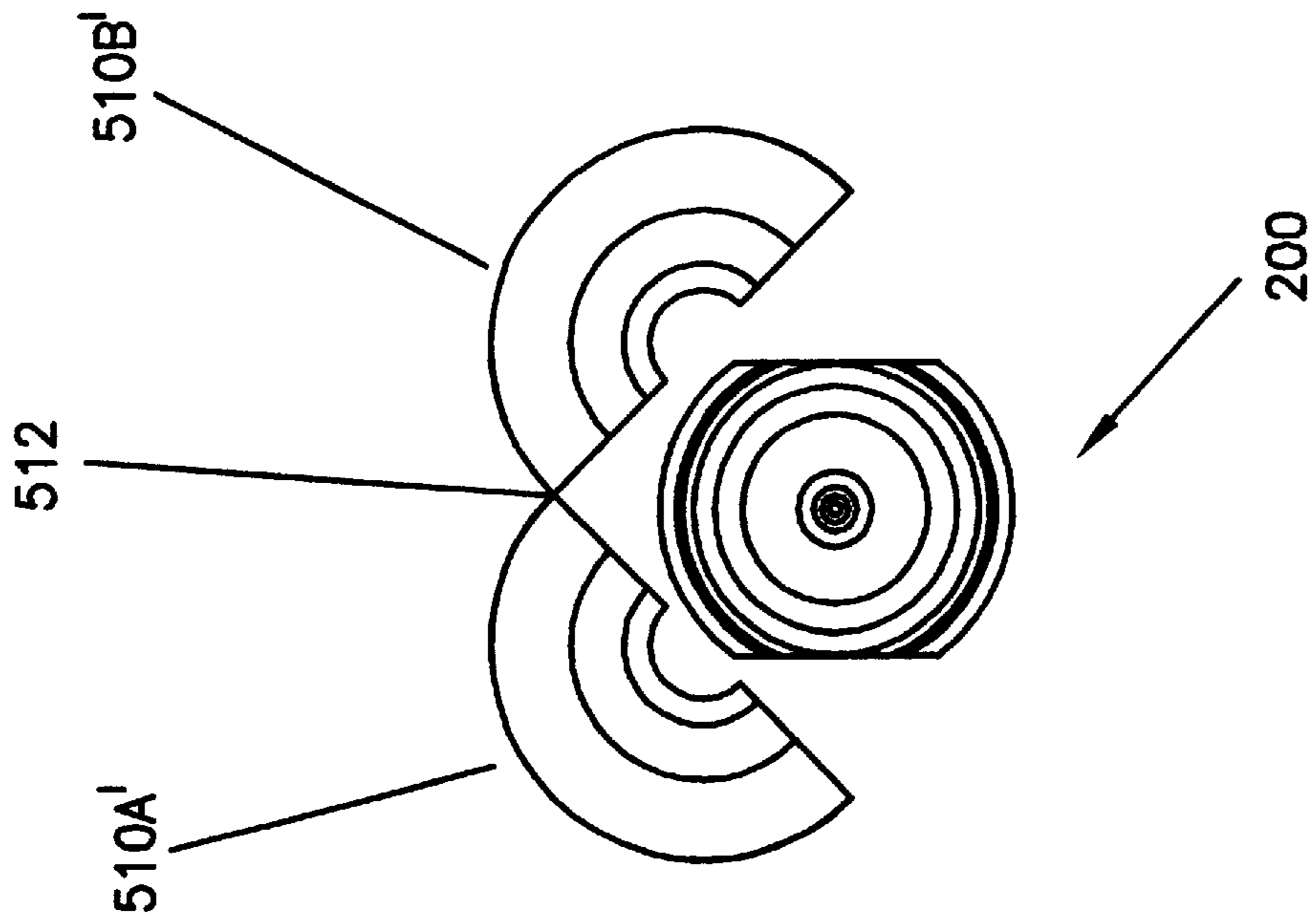


FIG. 6B

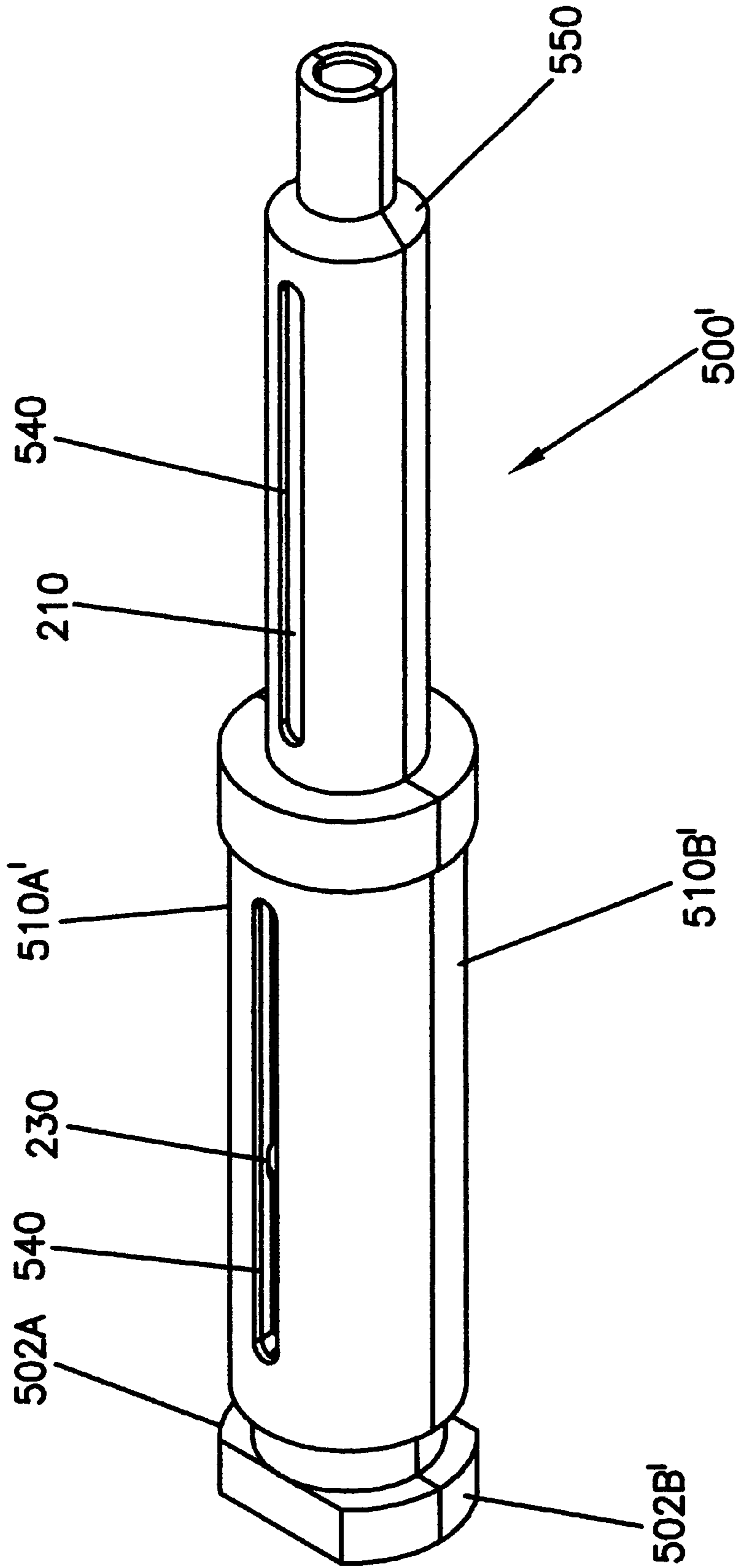


FIG. 6C

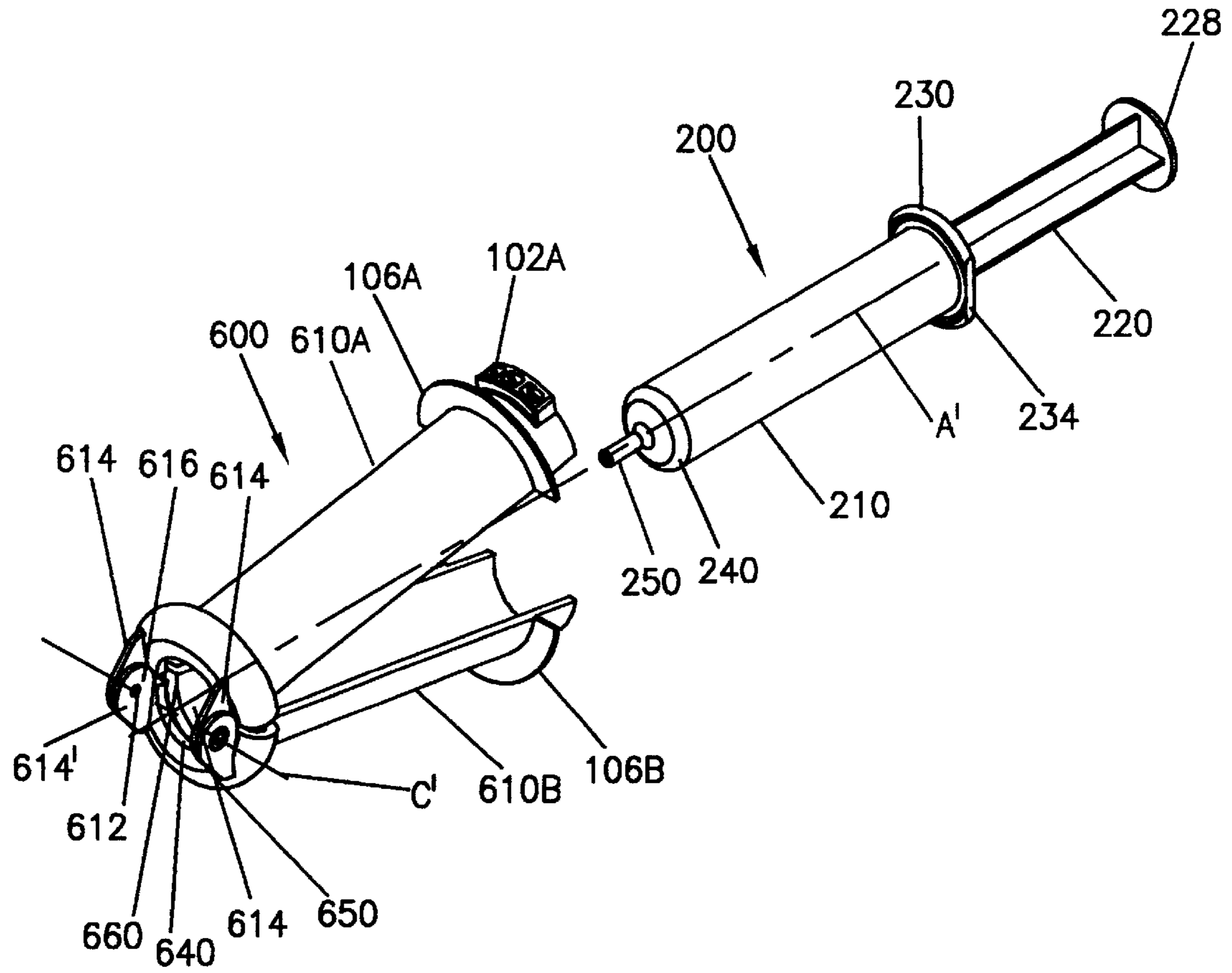
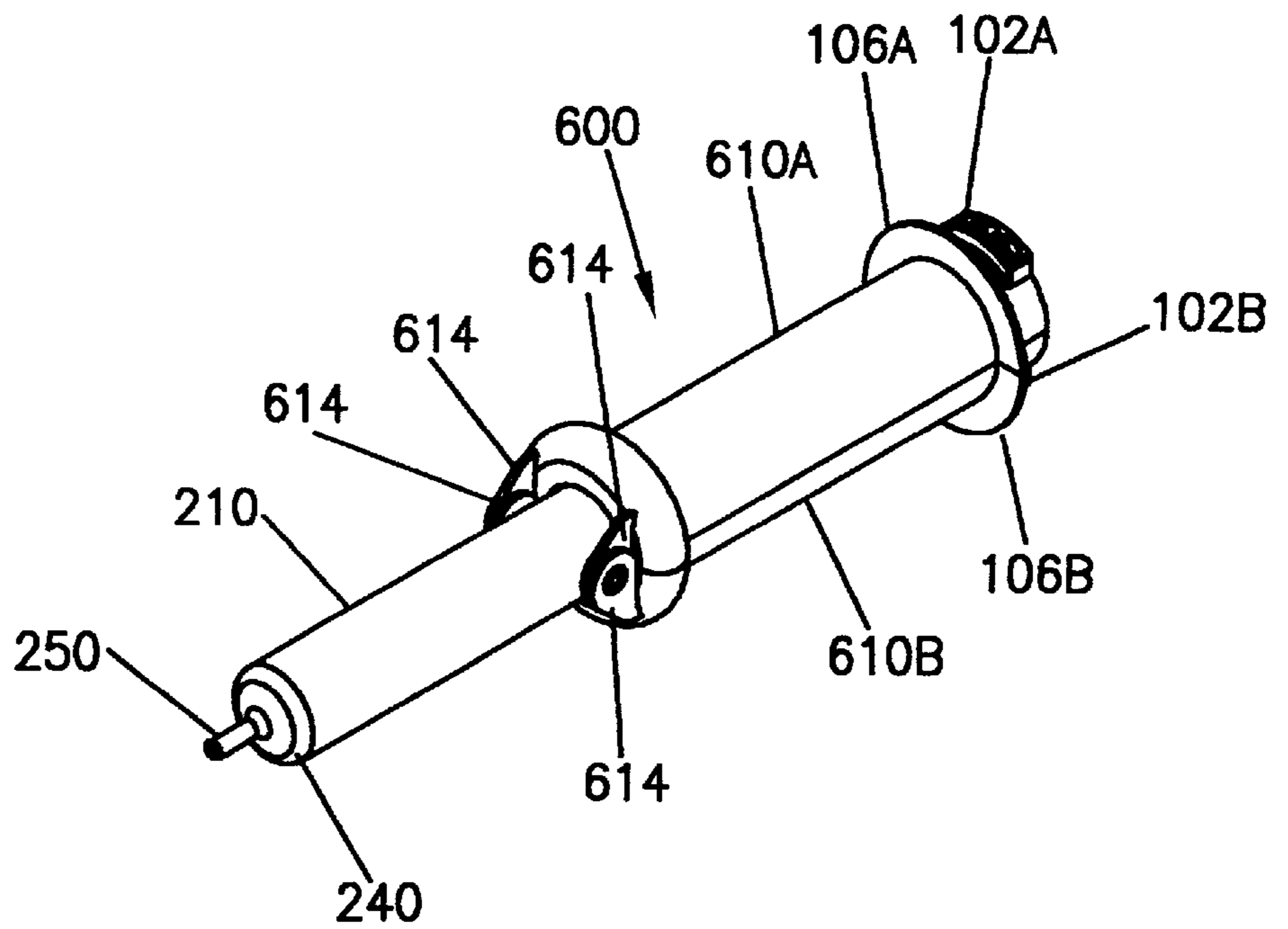
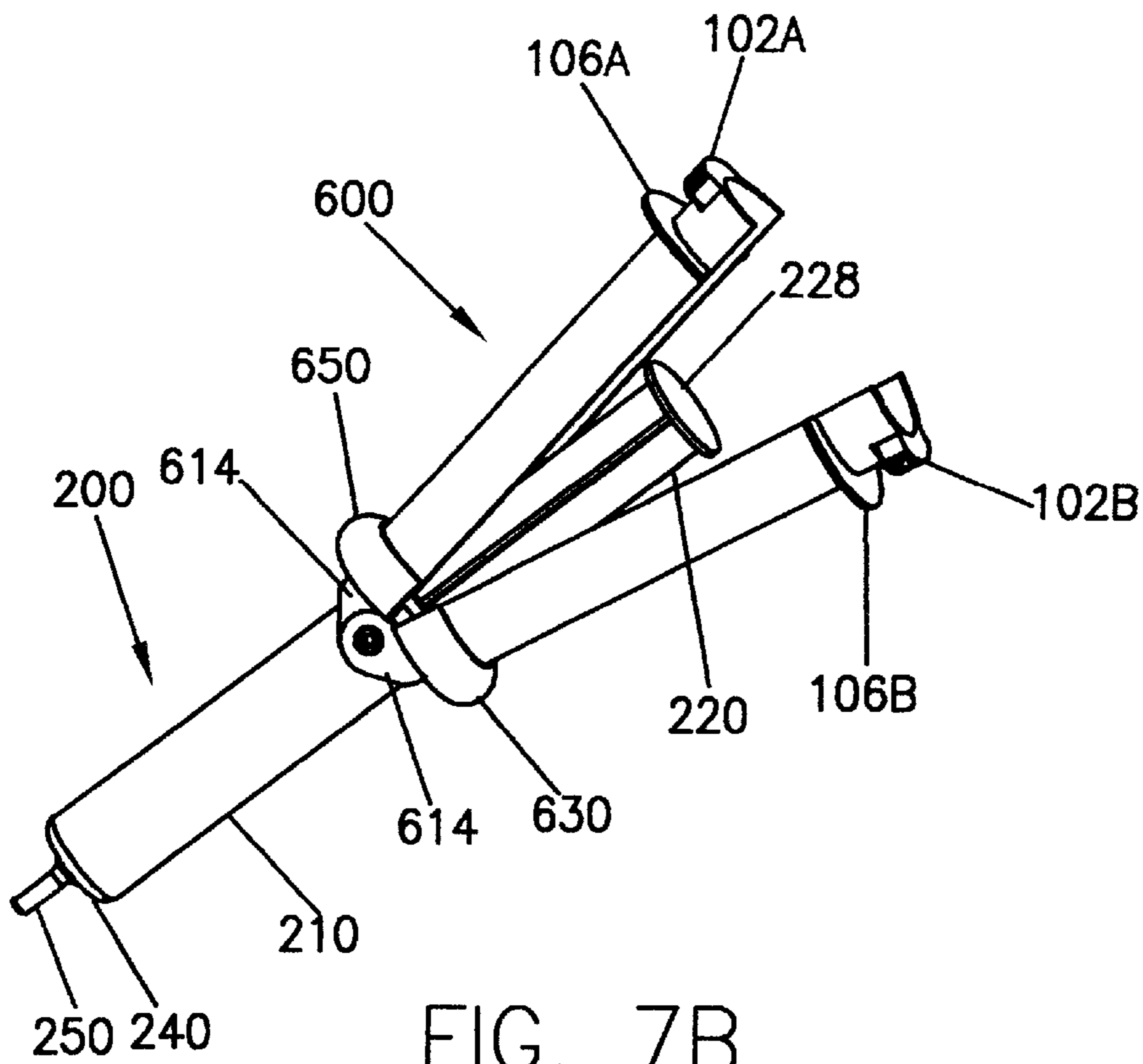


FIG. 7A



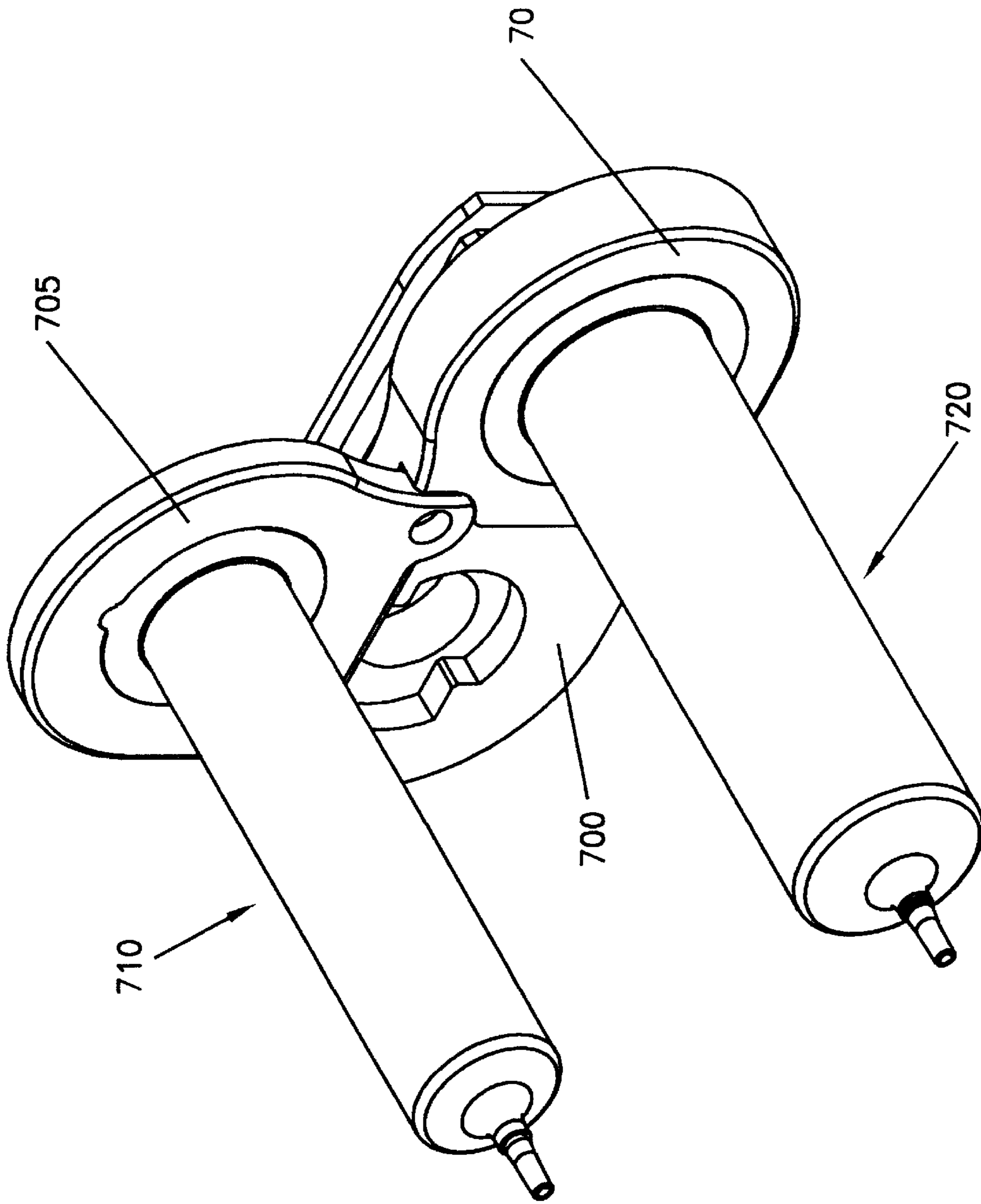


FIG. 8A

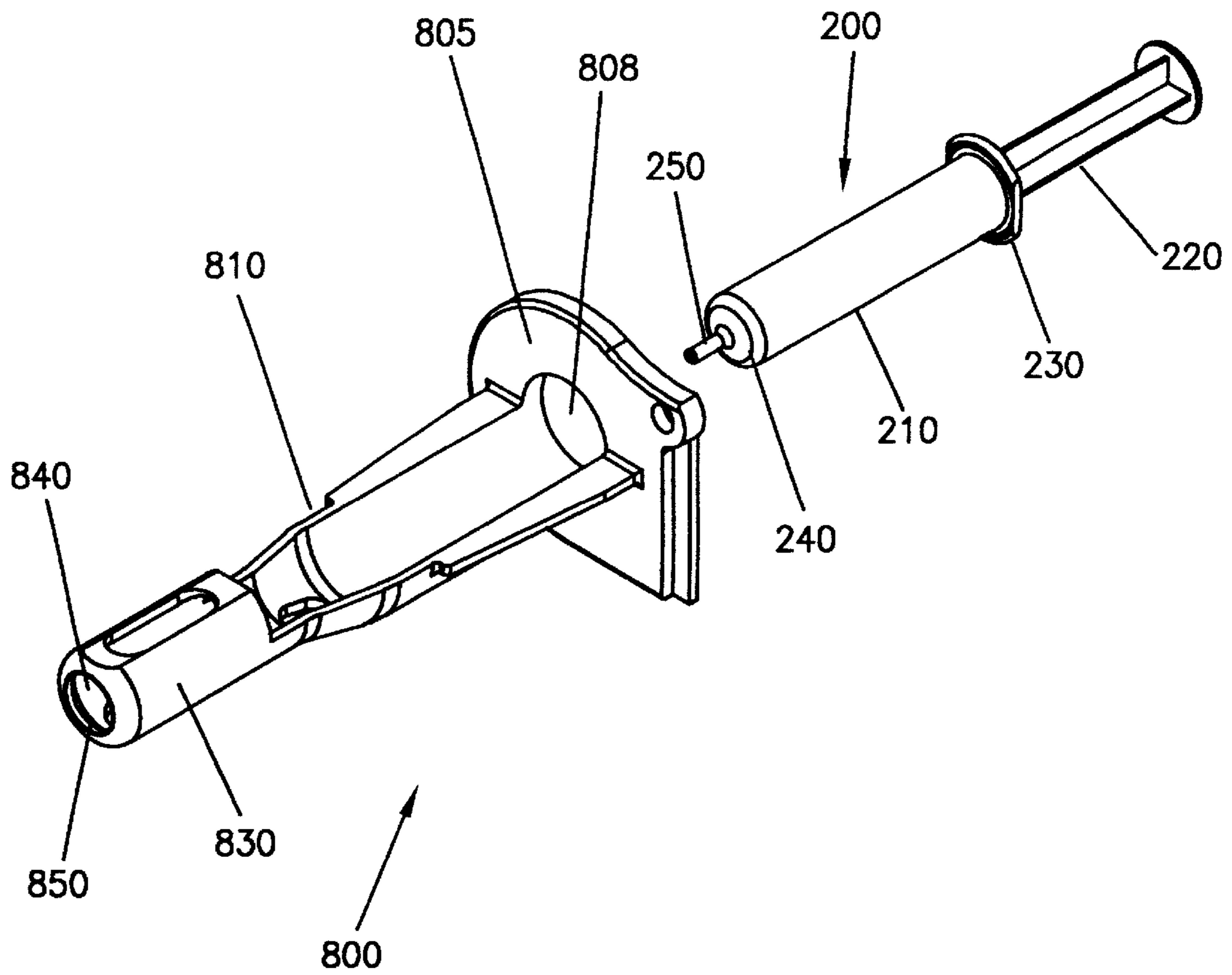


FIG. 8B

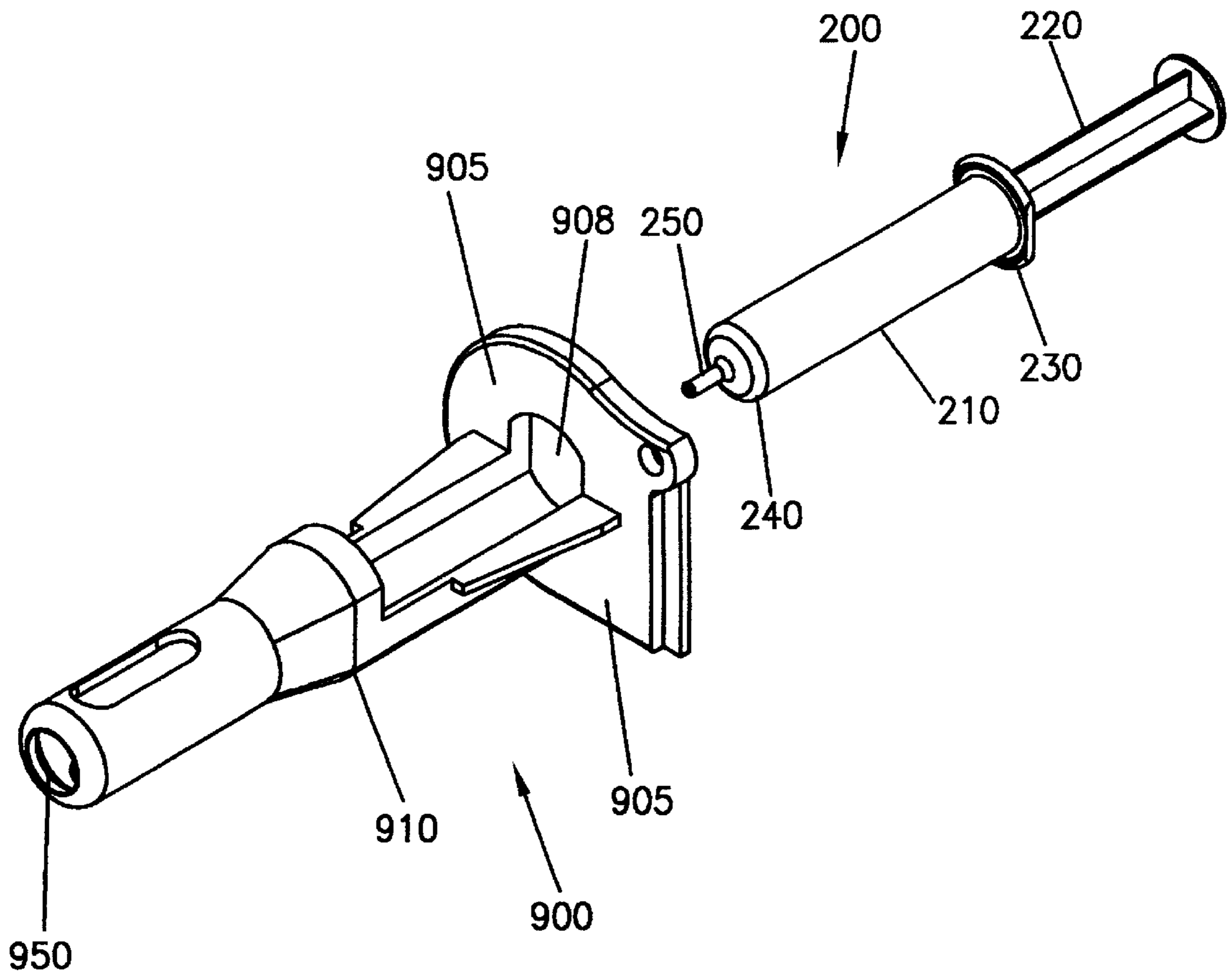


FIG. 8C

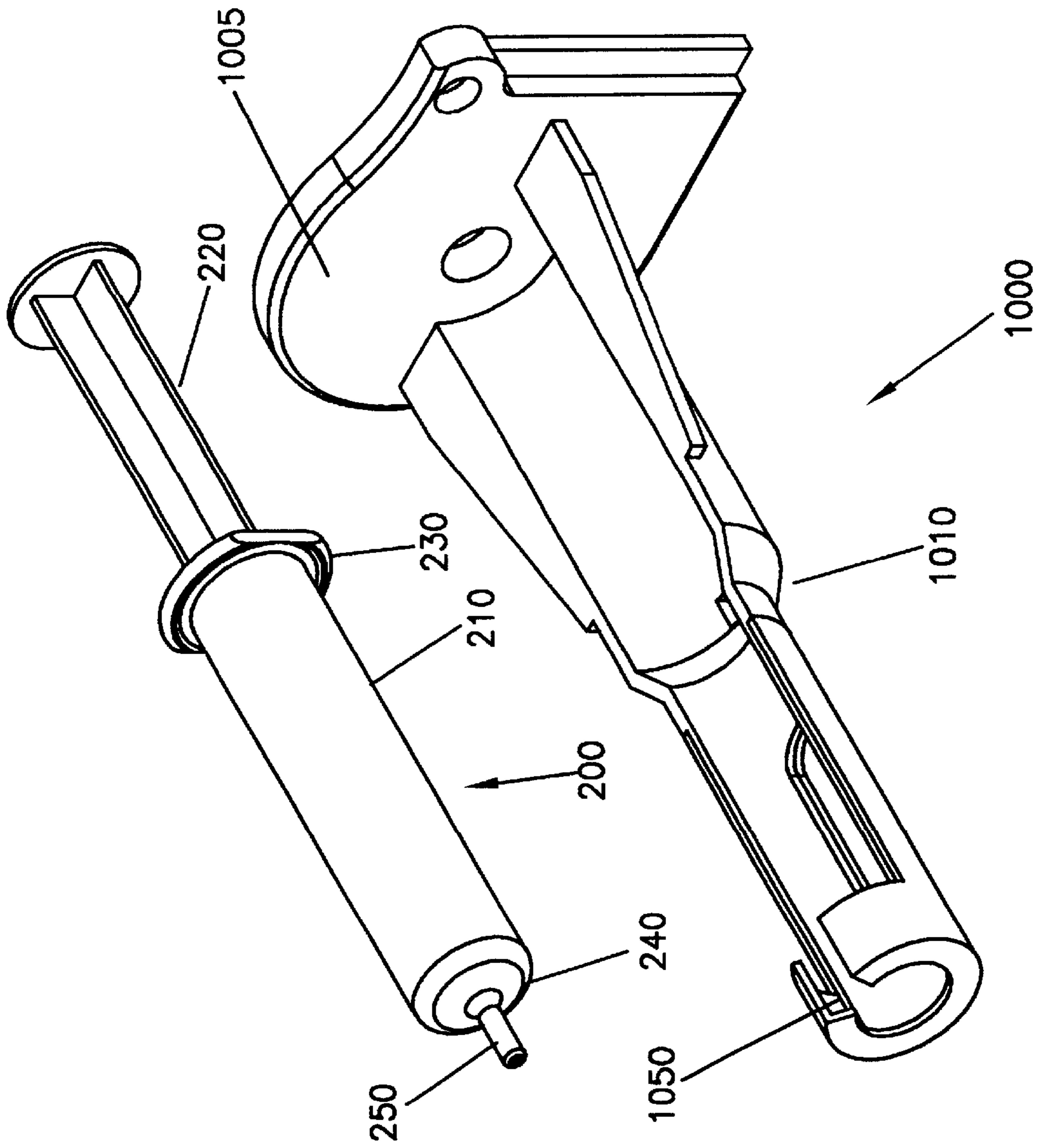


FIG. 8D

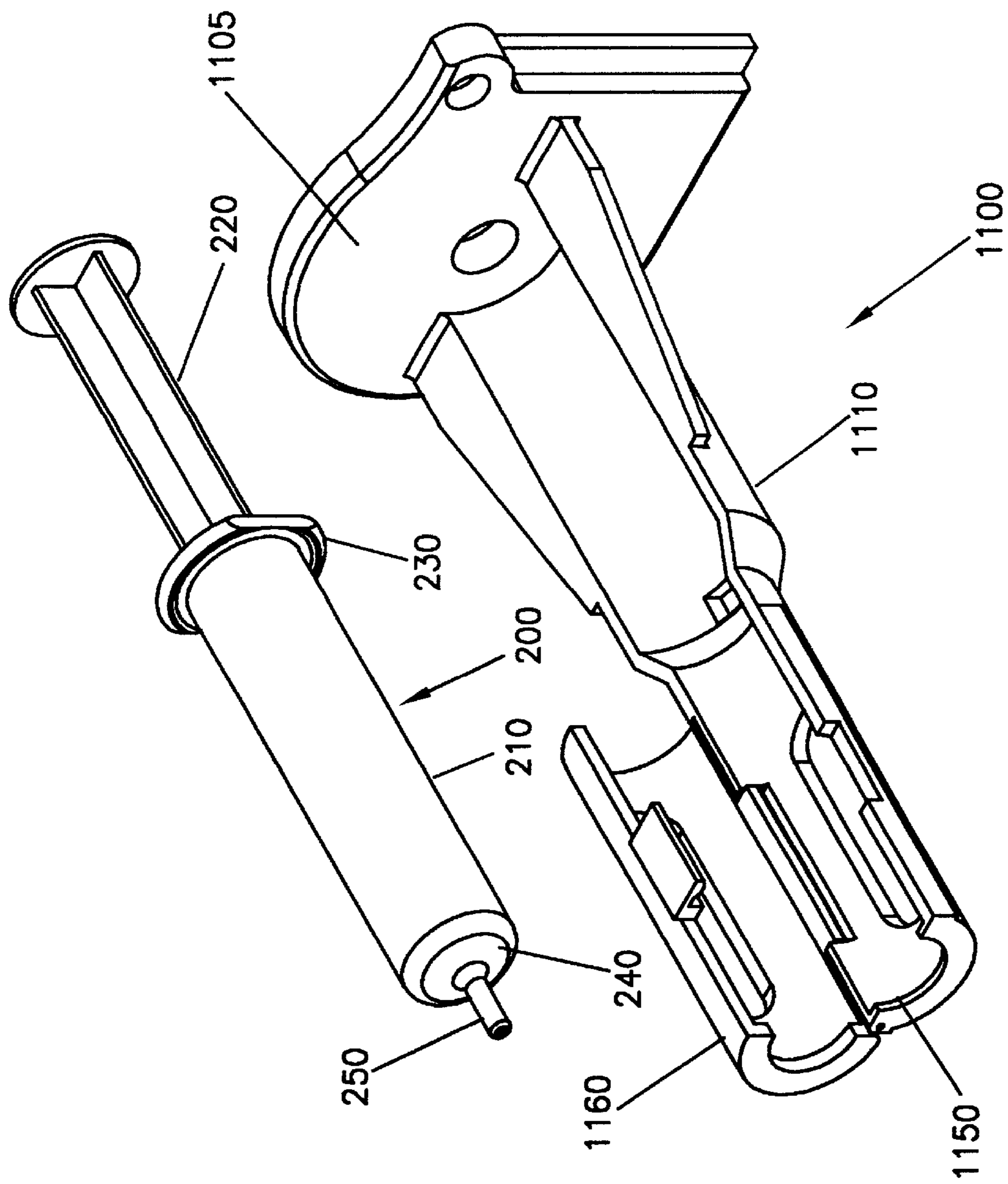


FIG. 8E

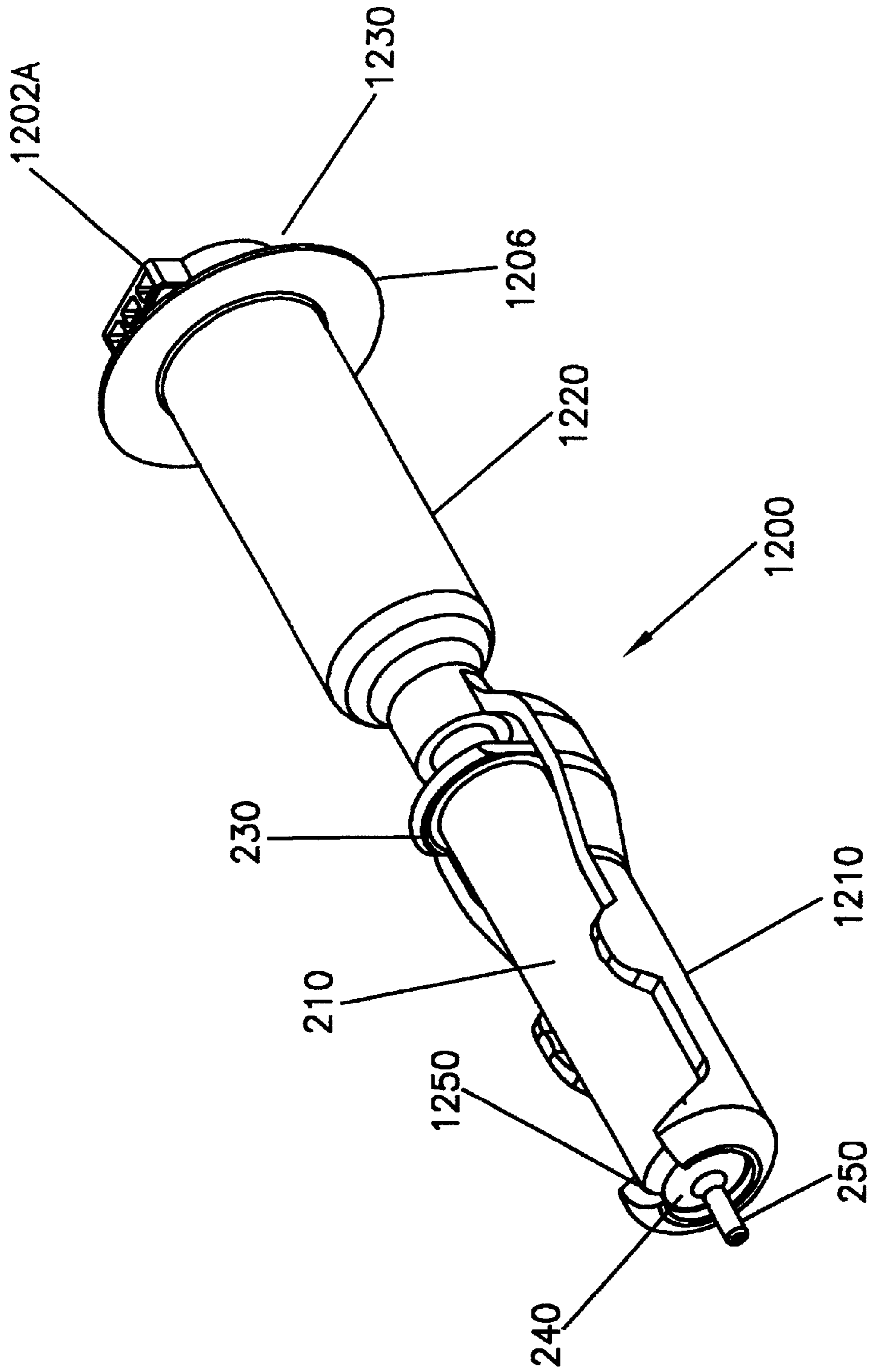


FIG. 9A

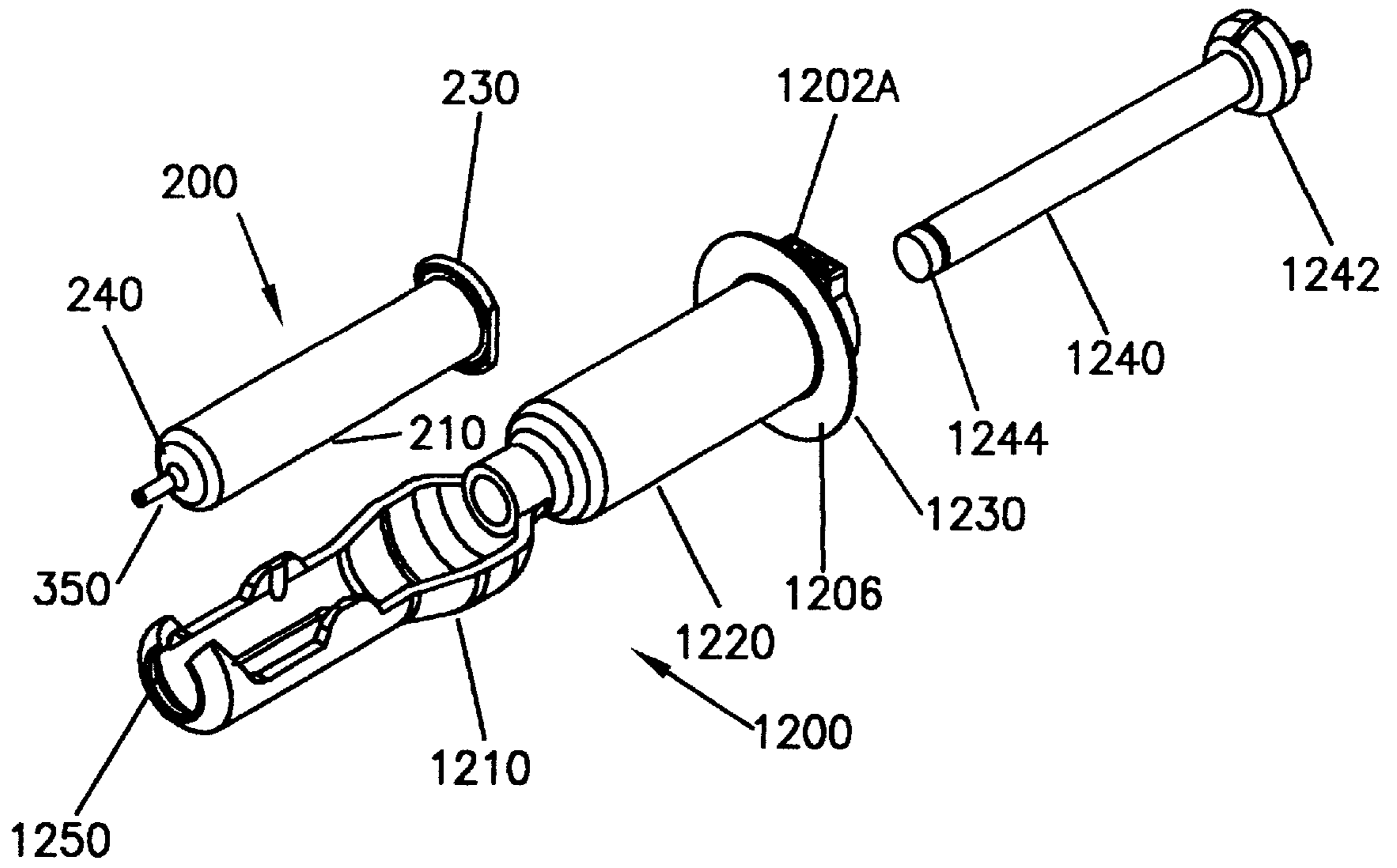


FIG. 9B

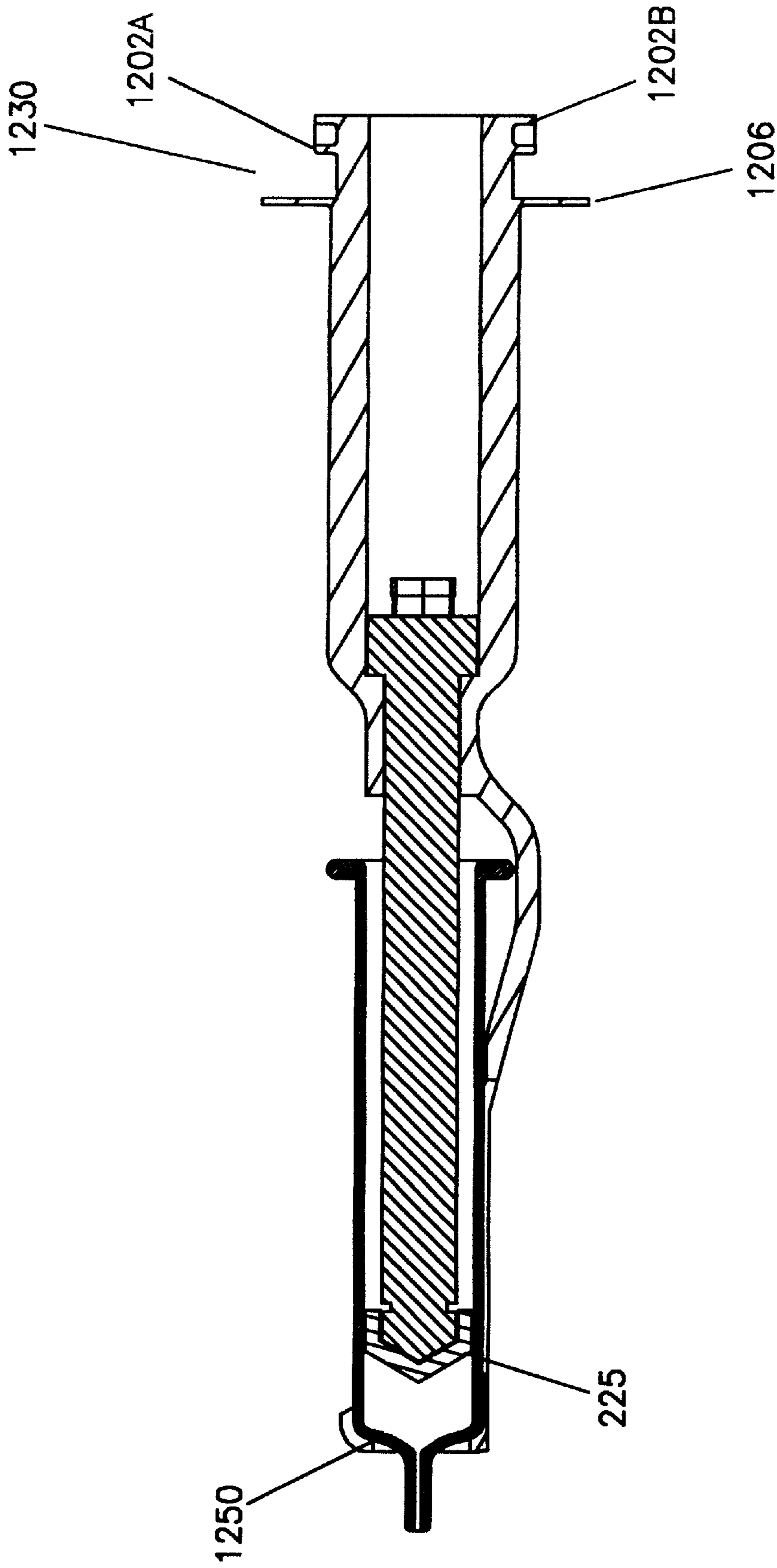


FIG. 9C

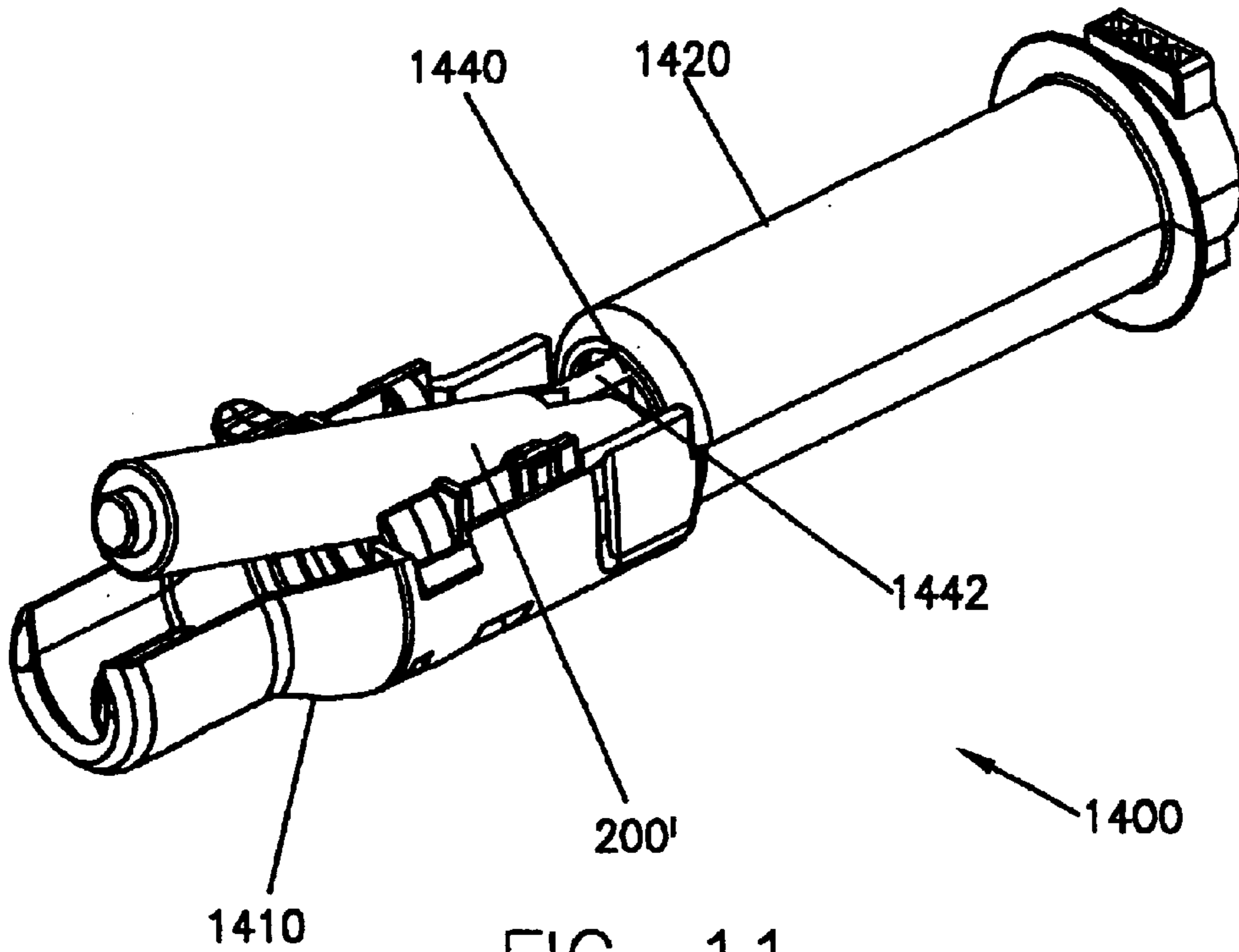


FIG. 11

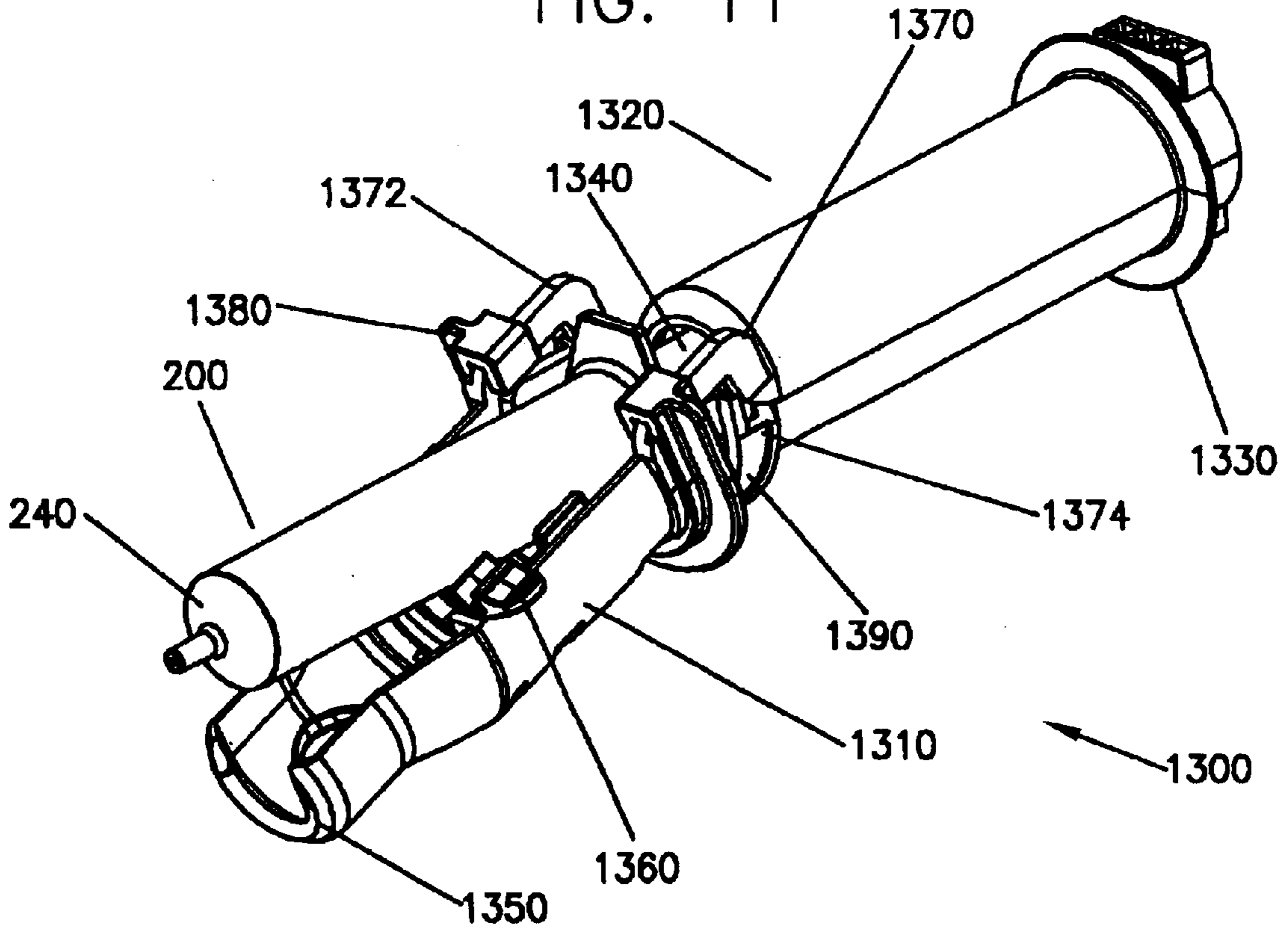


FIG. 10A

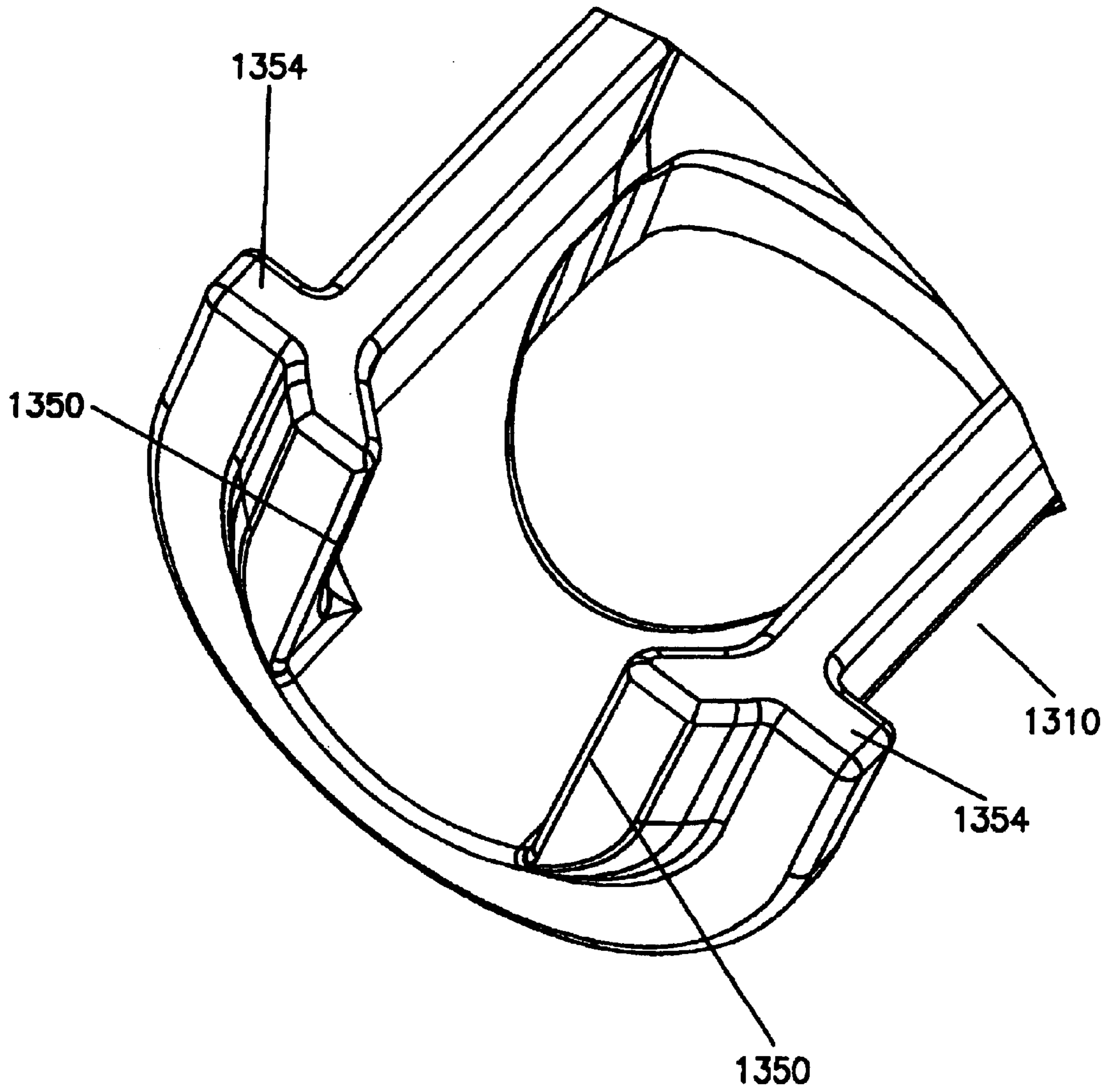


FIG. 10B

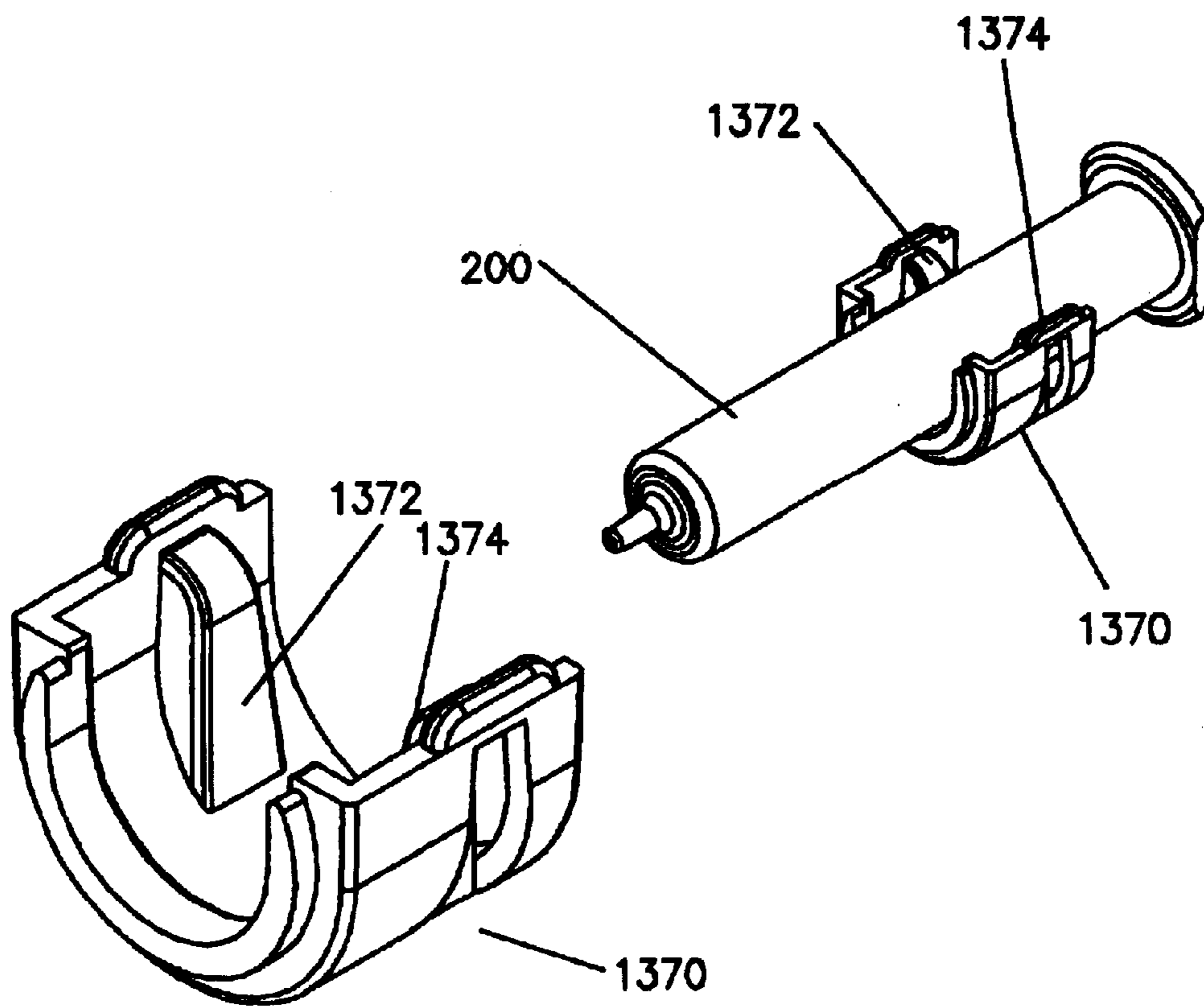


FIG. 10C

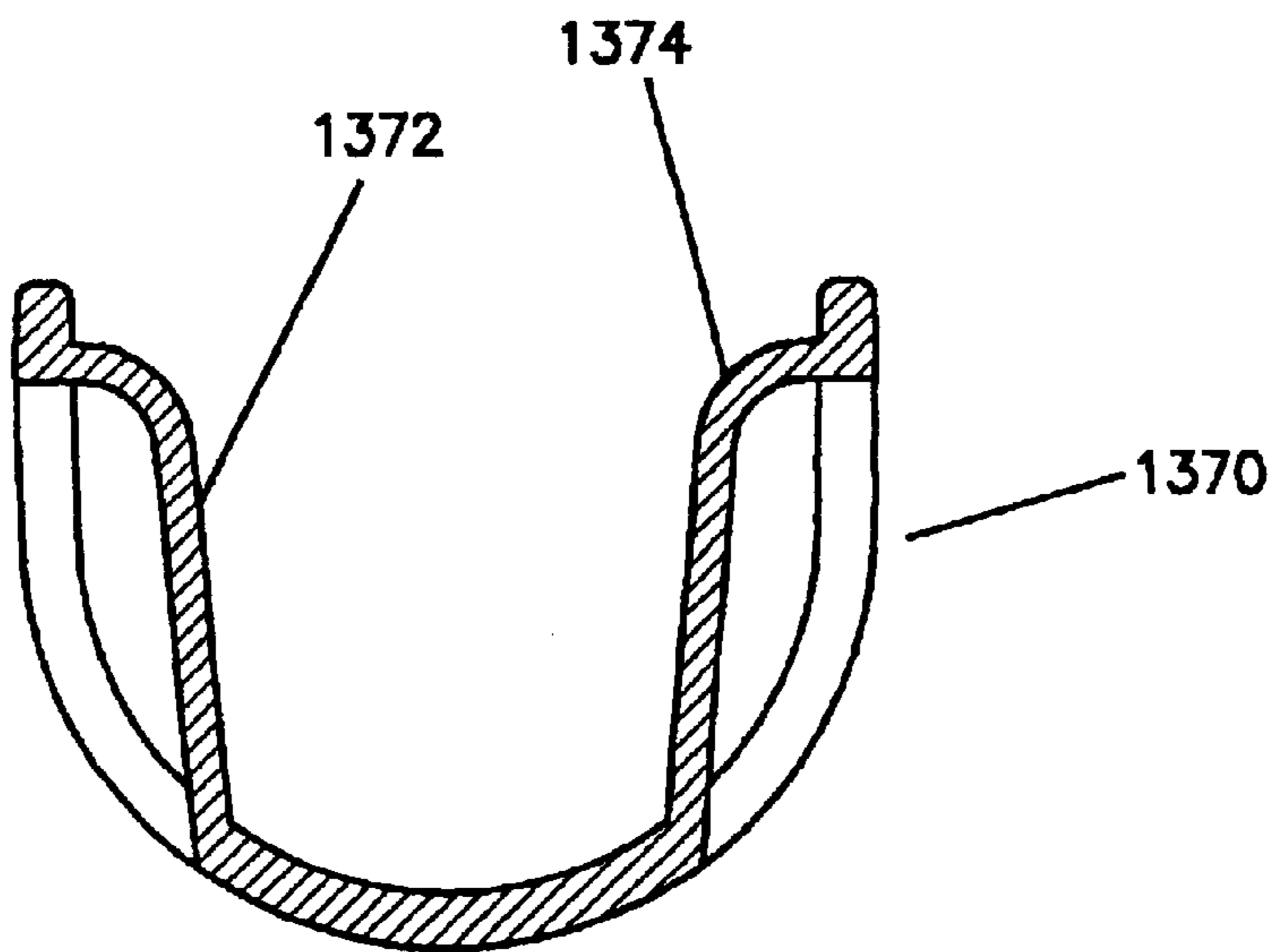


FIG. 10D

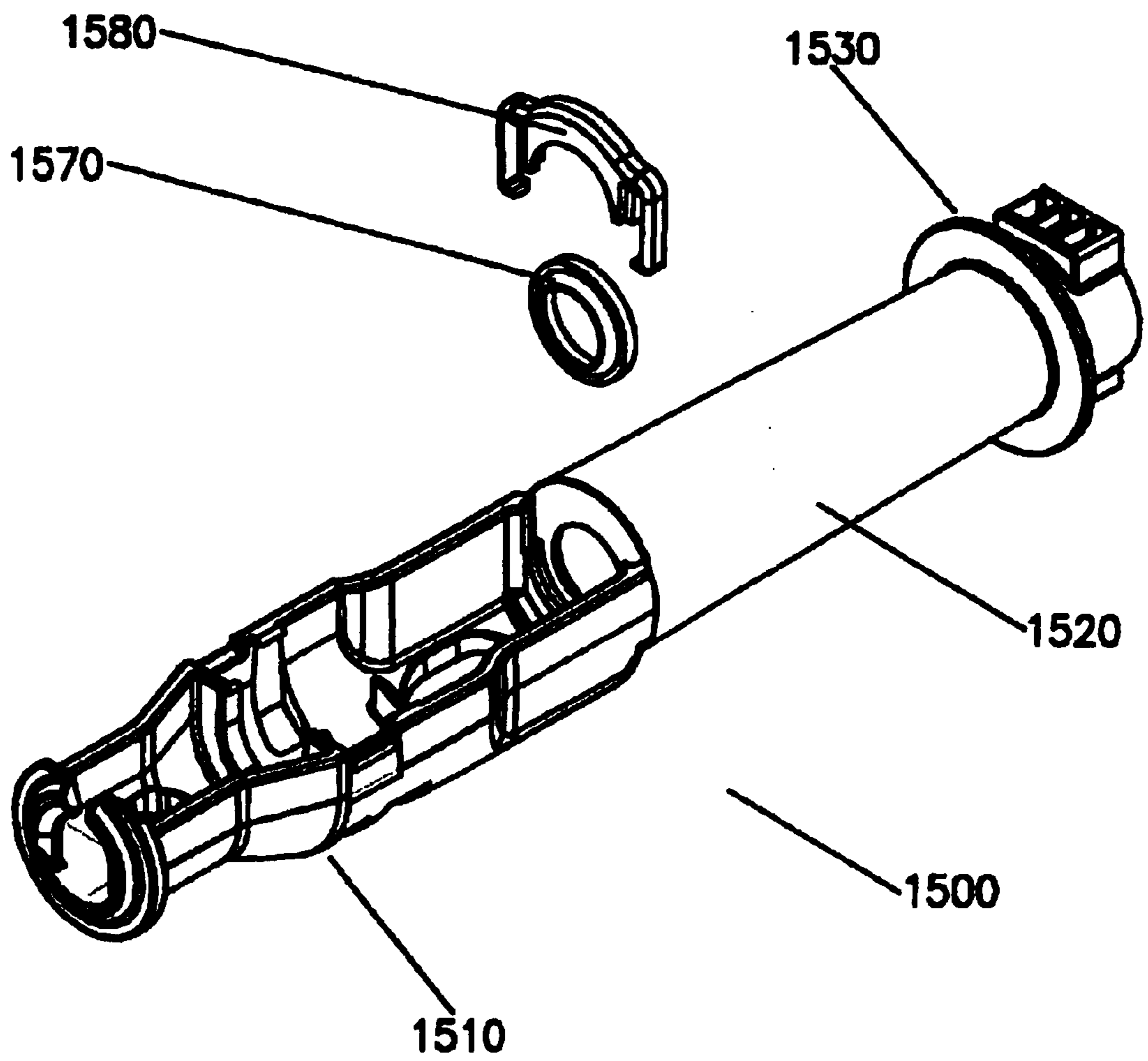


FIG. 12A

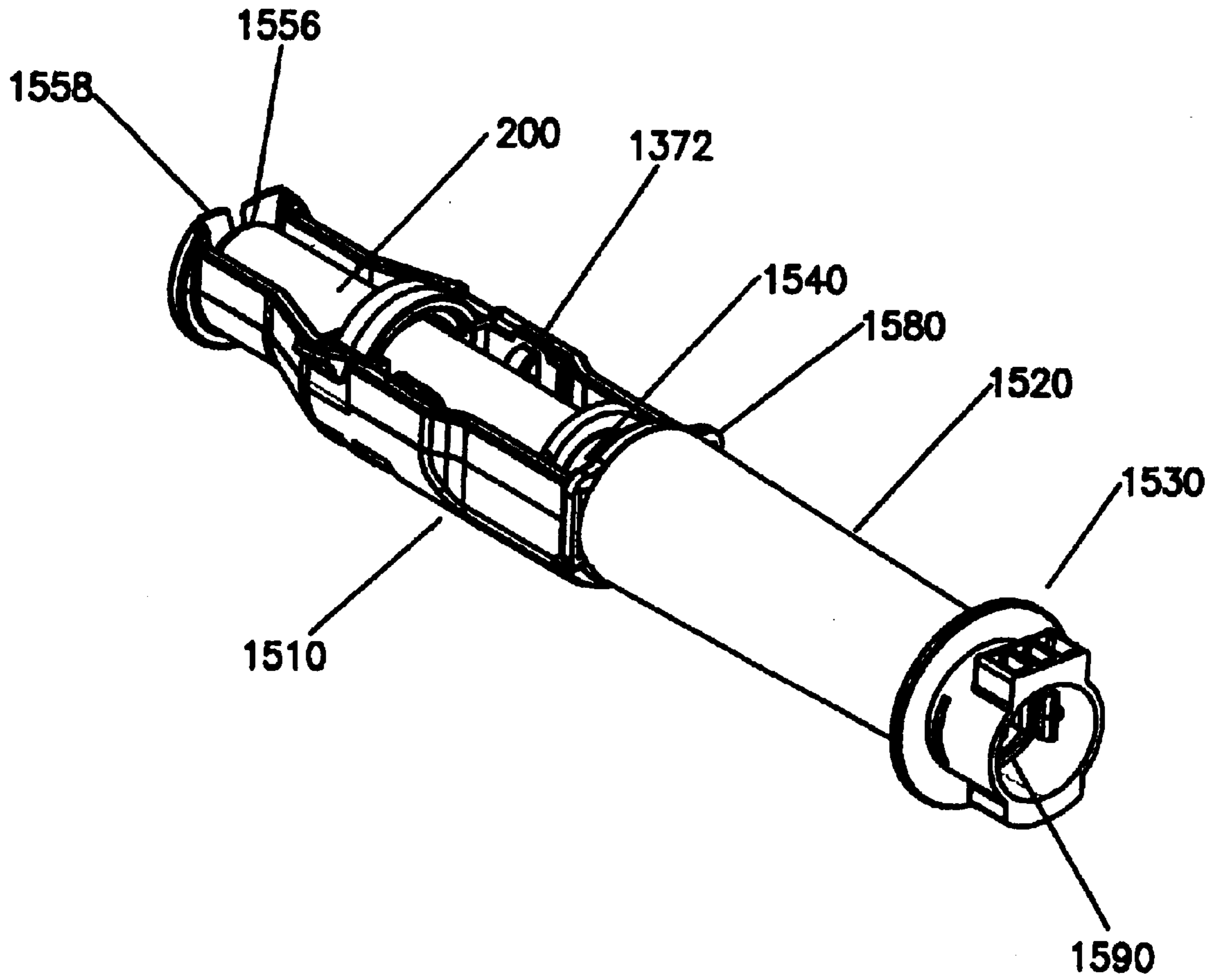


FIG. 12B

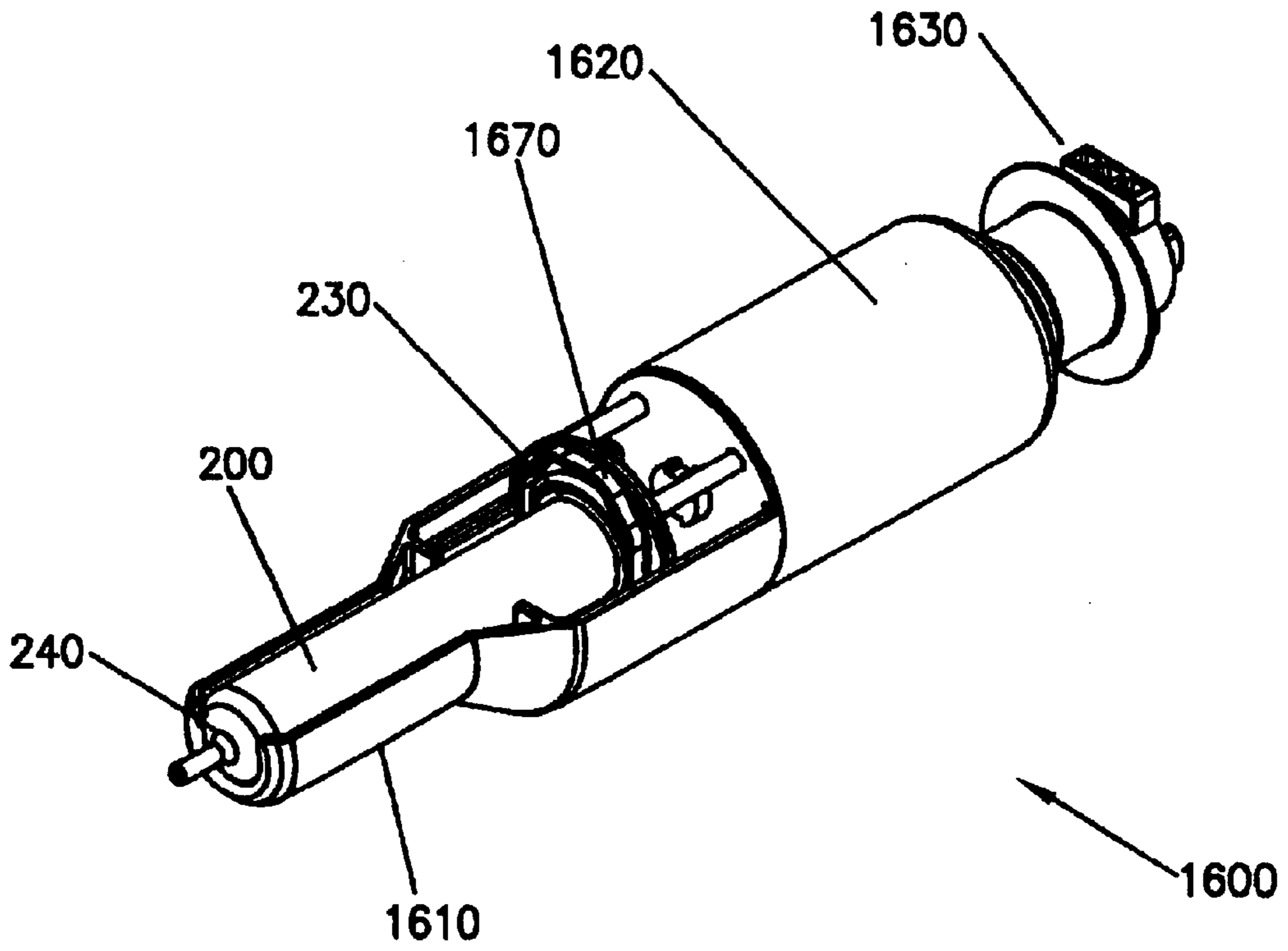


FIG. 13A

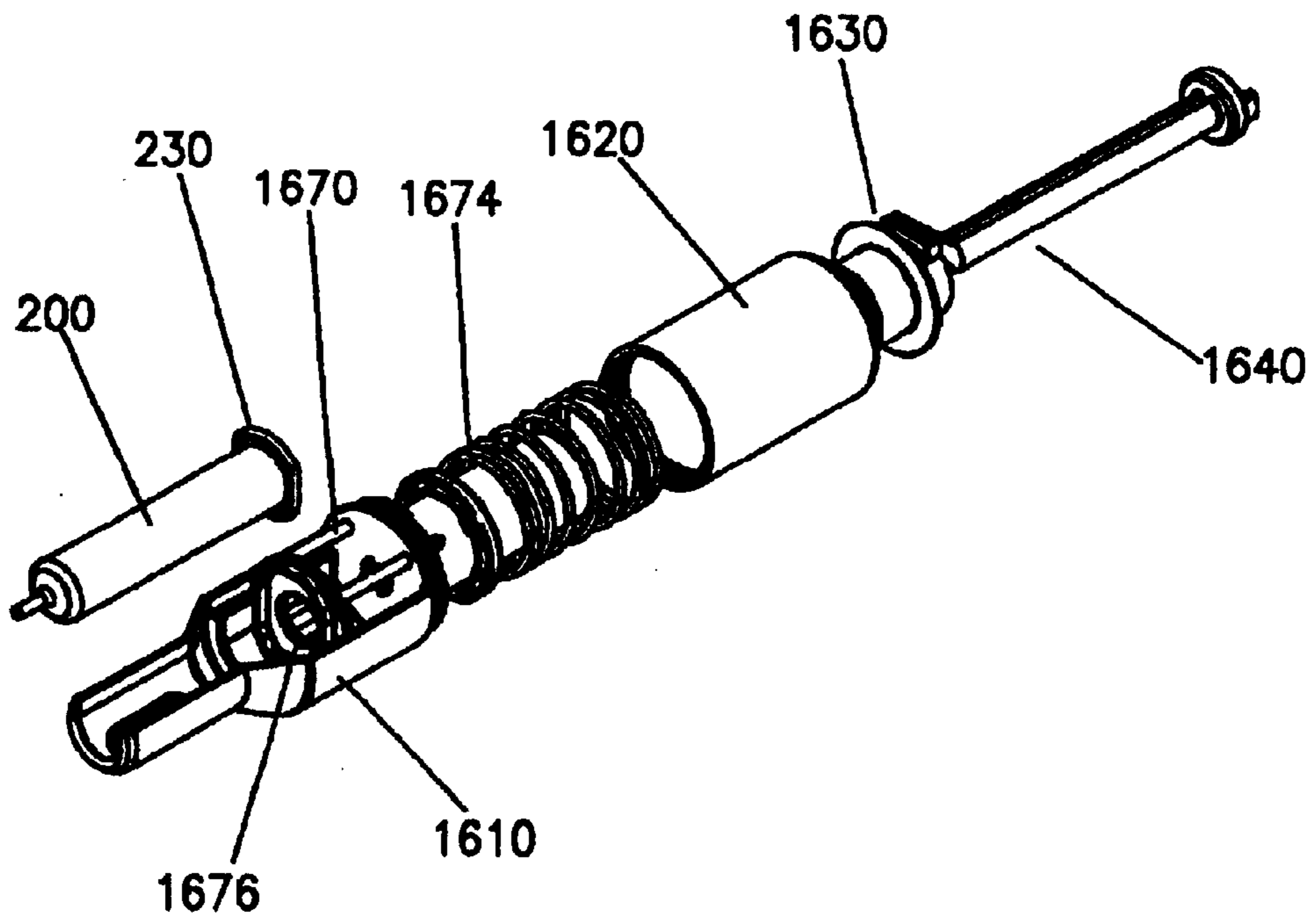


FIG. 13B

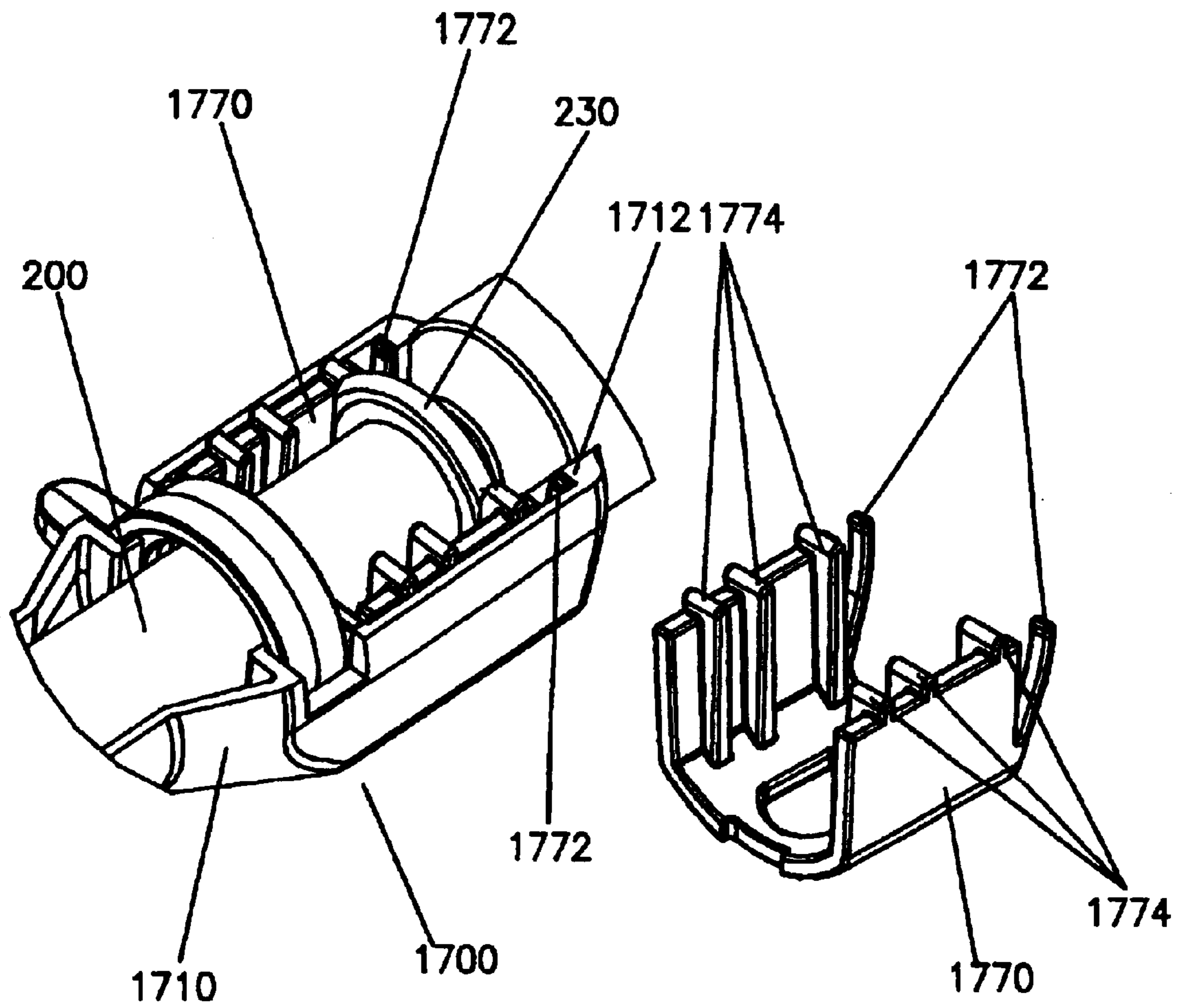


FIG. 14

INJECTOR SYSTEMS AND SYRINGE ADAPTERS FOR USE THEREWITH

RELATED APPLICATION

The present application is a continuation-in-part application of pending U.S. patent application Ser. No. 09/365,285 filed Jul. 30, 1999, the disclosure of which is incorporated herein by reference.

FIELD OF THE INVENTION

The present invention relates to powered injector systems and syringe adapters for use therewith.

BACKGROUND OF THE INVENTION

A number of injector-actuated syringes and powered injectors for use in medical procedures such as angiography, computed tomography, ultrasound and NMRIMRI have been developed. U.S. Pat. No. 4,006,736, for example, discloses an injector and syringe for injecting fluid into the vascular system of a human being or an animal. Typically, such injectors comprise drive members such as pistons that connect to a syringe plunger. For example, U.S. Pat. No. 4,677,980, the disclosure of which is incorporated herein by reference, discloses an angiographic injector and syringe wherein the drive member of the injector can be connected to, or disconnected from, the syringe plunger at any point along the travel path of the plunger via a releasable mechanism. A front-loading syringe and injector system is also disclosed in U.S. Pat. No. 5,383,858, the disclosure of which is incorporated herein by reference.

As discussed in U.S. Pat. No. 5,383,858, a syringe used with a front-loading injector preferably includes a readily releasable mounting mechanism for securing the syringe to the front wall of the injector. The use of specifically designed mounting mechanisms, however, prevents the use of syringes of other various types with front-loading injectors. Such syringes may, for example, include a syringe body, a plunger reciprocally mounted therein, and a plunger extension for transfer of force to the plunger.

U.S. Pat. No. 5,520,653, the disclosure of which is incorporated herein by reference, discloses several adapters designed to allow the use of various syringes with a front-loading injector. In one embodiment, the adapter of U.S. Pat. No. 5,520,653 includes a syringe carrier having a front end, a rear end, and syringe retaining channel located between the carrier front and rear ends for engaging at least a portion of the syringe flange. Mounting flanges near the rearward end of the carrier to releasably mount the carrier in a desired position relative to the front wall of the injector. The adapter of U.S. Pat. No. 5,520,653 further includes a follower reciprocally mounted within the carrier. The follower has a front end that engages the syringe plunger extension when the syringe is installed in the carrier. A drive head opening in the carrier communicates with a pair of drive head slots positioned near the rear end of the follower for releasably mounting the follower in a desired position relative to the drive head of the injector.

Although U.S. Pat. No. 5,520,653 is a substantial improvement in the art, it remains desirable to develop improved adapters for use with syringes of various types to permit use of such syringes with front-loading injectors.

SUMMARY OF THE INVENTION

In general, the present invention provides an adapter for releasably mounting a syringe in a desired position relative

to a front-loading powered injector. The syringe includes a body and a plunger slideably positioned within the body. The injector includes a front wall, an opening formed in the front wall, and a drive member reciprocally mounted in the injector. The adapter preferably includes generally a syringe carrier adapted to seat at least a portion of the syringe. The syringe carrier includes at least one rearward facing abutment member to abut at least one forward facing surface on the syringe. The syringe carrier includes an opening therein to allow the drive member of the injector to communicate forward force to the plunger through abutment without connective engagement between the drive member and the plunger. The adapter further includes a releasable mounting mechanism positioned to the rear of the syringe carrier to mount the adapter in a desired position relative to the front wall of the injector.

The syringe may further include a transition region over which the radius or width of the syringe decreases (for example, a generally frusto-conical region) attached to a forward end of the body. The abutment member may abut a forward facing surface created by the transition region. Preferably, the abutment member abuts the transition region only in the vicinity of the transition from the body to the generally frusto-conical region (for example, at to the outer edge of the transition region).

The syringe may further include a syringe flange attached to a rearward end of the body of the syringe. The abutment member may abut a forward facing surface of the syringe flange. Preferably, the abutment member abuts the syringe flange only in the vicinity of the transition from the body to the syringe flange.

In one embodiment, the adapter includes a first section and a second section rotatable relative to each other about a hinge axis generally perpendicular to a longitudinal axis of the adapter. The first section and the second section are preferably rotatable about the hinge axis to an open position to allow loading of the syringe into the adapter from a position to the rear of the hinge axis. The first section and the second section are also preferably rotatable about the hinge axis to a closed position to form the syringe carrier.

In another embodiment, the adapter includes a first section and a second section that are generally the same in construction. The first section and the second section are connectable to form the syringe carrier and the releasable mounting mechanism.

The present invention also provides an adapter for releasably mounting a syringe in a desired position relative to a powered injector. The syringe preferably includes a body and a plunger slideably positioned within the body as discussed above. The injector preferably includes a front wall, an opening formed in the front wall, and a drive member reciprocally mounted in the injector. The adapter includes a first section and a second section that are rotatable relative to each other about a hinge axis generally perpendicular to a longitudinal axis of the adapter to an open position to allow loading of the syringe into the adapter from a position to the rear of the hinge axis. The first section and the second section are also preferably rotatable about the hinge axis to a closed position to form a syringe carrier to seat at least a portion of the syringe.

The present invention also provides an adapter for releasably mounting a syringe in a desired position relative to a powered injector. The adapter preferably includes a first section and a second section that are of generally the same in construction. The first section and the section are connectable to form a syringe carrier to seat at least a portion of

the syringe. Preferably, the first section and the section also form a releasable mounting mechanism positioned to the rear of the syringe carrier to mount the adapter in a desired position relative to the front wall of the injector.

In another aspect, the present invention provides an adapter for releasably attaching a syringe to a front-loading powered injector including a releasable mounting mechanism positioned at a rear of the adapter to mount the adapter in a desired position relative to the front wall of the injector. The adapter also includes a syringe carrier section adapted to seat at least a portion of the syringe. The syringe carrier section is preferably open along the length of the top thereof to allow placement of the syringe therein from the top. A portion of the syringe carrier section abuts the transition region of the syringe in a manner that the force exerted by the syringe on the adapter is generally symmetrical about an axis of the adapter during an injection, thereby reducing any bending moment about the mounting mechanism. The syringe carrier section also includes an opening in a rear section thereof to allow the drive member of the injector to communicate forward force to the syringe plunger. The portion of the syringe carrier section abutting the transition region of the syringe can, for example, include a first abutment surface positioned on a first lateral side of the syringe carrier section and a second abutment surface positioned on a second lateral side of the carrier section.

In another aspect, the present invention provides an adapter for releasably attaching a syringe to a front-loading powered injector including an intermediate section through which a push rod can pass to communicate force from the injector drive member to the plunger. The intermediate section has a releasable mounting mechanism positioned at a rear thereof to mount the adapter in a desired position relative to the front wall of the injector. The adapter also includes a syringe carrier section connected to the intermediate section. The syringe carrier section is adapted to seat at least a portion of the syringe and includes an opening in a rear section thereof to allow the drive member of the injector to communicate forward force to the plunger via the push rod.

The syringe carrier section is preferably open on a top thereof. A forward portion of the syringe carrier section abuts the transition region of the syringe during injection. The syringe carrier section is movable relative to the intermediate section to move the forward portion out of contact with the transition region of the syringe to enable removal of the syringe without retraction of the drive member. In one aspect, for example, the carrier section is connected to the intermediate section in a hinging manner.

In another aspect, an adapter system of the present invention includes an intermediate section having a releasable mounting mechanism positioned at a rear thereof as described above. The adapter system also includes a syringe carrier section connected to the intermediate section and adapted to seat at least a portion of the syringe. The syringe carrier section includes an opening in a rear section thereof to allow the drive member of the injector to communicate forward force to the plunger from the drive member and is preferably open on a top thereof. A forward portion of the syringe carrier section abuts the transition region of the syringe during an injection procedure. The adapter system further includes a push rod used to communicate force from the injector drive member to the plunger. The pushrod has a forward section that is movable relative to a rearward section of the pushrod to allow movement of the transition region of the syringe out of contact with the forward portion of the syringe carrier section to enable removal of the

syringe from the adapter without retraction of the drive member. The forward section of the push rod can, for example, be rotatable, hingeable or removable relative to the rearward section of the push rod.

Another adapter system of the present invention includes a releasable mounting mechanism positioned at a rear of the adapter to mount the adapter in a desired position relative to the front wall of the injector as described above and a pushrod to communicate force from the drive member to the plunger. The adapter system also includes a syringe carrier section adapted to seat at least a portion of the syringe. The syringe carrier section includes an opening in a rear section thereof to allow passage of the pushrod therethrough to contact to the plunger. The adapter system further includes a contact member preferably positioned in the syringe carrier section to contact the pushrod and prevent a fluid from the syringe from passing rearward of the sealing member. The contact member can, for example, include a wiper seal.

In another aspect, the present invention provides an adapter including a releasable mounting mechanism and a syringe carrier section adapted to seat at least a portion of the syringe. The syringe carrier section is preferably open on a top thereof to allow placement of the syringe therein or removal of the syringe therefrom from the top. The syringe carrier section includes at least one flexing retainer therein to place pressure on at least one side of the syringe to retain the syringe within the syringe carrier section. The syringe carrier section further includes an opening in a rear section thereof to allow the drive member of the injector to communicate forward force to the plunger.

In still a further aspect, the present invention provides an adapter for releasably attaching a syringe to a front-loading powered injector including a releasable mounting mechanism as described above and a syringe carrier section adapted to seat at least a portion of the syringe. A forward abutment portion of the syringe carrier section abuts the transition region of the syringe. The syringe carrier section includes a biasing member to contact a rear surface of the syringe. The biasing member forces or biases the transition region of the syringe against the forward abutment portion for syringes of various lengths. The biasing member can, for example, be biased forward by a spring. The biasing member can also, for example, be biased forward by flexible member on a rear side thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

Other aspects of the invention and their advantages will be discerned from the following detailed description when read in connection with the accompanying drawings, in which:

FIG. 1A illustrates an embodiment of an injector system of the present invention for use in connection with an MRI procedure.

FIG. 1B illustrates the injector system of FIG. 1A in which the saline syringe and the adapter have been disassembled from the injector.

FIG. 2A illustrates a perspective view of an embodiment of an adapter of the present invention in an open state for loading of a syringe therein.

FIG. 2B illustrates a perspective view of the adapter of FIG. 2A in an open state with a syringe loaded therein.

FIG. 2C illustrates a perspective view of the adapter of FIG. 2A in a closed state with a syringe loaded therein.

FIG. 2D illustrates a plan view of the adapter of FIG. 2A in a closed state with a syringe loaded therein.

FIG. 2E illustrates a side, cross-sectional view of the adapter of FIG. 2A in a closed state with a syringe loaded therein.

FIG. 3A illustrates a perspective view of another embodiment of an adapter of the present invention in an open state for loading of a syringe therein.

FIG. 3B illustrates a perspective view of the adapter of FIG. 3A in an open state with a syringe loaded therein.

FIG. 3C illustrates a perspective view of the adapter of FIG. 3A in a closed state with a syringe loaded therein.

FIG. 3D illustrates a plan view of the adapter of FIG. 3A in a closed state with a syringe loaded therein.

FIG. 3E illustrates a side, cross-sectional view of the adapter of FIG. 3A in a closed state with a syringe loaded therein.

FIG. 4A illustrates a perspective view of another embodiment of an adapter of the present invention with a syringe positioned to be inserted therein.

FIG. 4B illustrates a perspective view of the adapter of FIG. 4A with the syringe positioned therein.

FIG. 4C illustrates a perspective view of the adapter of FIG. 4A wherein a syringe retaining member is in a closed position.

FIG. 4D illustrates a perspective view of an adapter including another embodiment of a syringe retaining member.

FIG. 4E illustrates a perspective view of an adapter including another embodiment of a syringe retaining member.

FIG. 4F illustrates a perspective view of an adapter including another embodiment of a syringe retaining member.

FIG. 4G illustrates a perspective view of an adapter including another embodiment of a syringe retaining member.

FIG. 4H illustrates a perspective view of an adapter including another embodiment of a syringe retaining member.

FIG. 4I illustrates a perspective view of an adapter including another embodiment of a syringe retaining member.

FIG. 5A illustrates a perspective view of an embodiment of an adapter including separate, generally identical sections in an unconnected state.

FIG. 5B illustrates a perspective view of the adapter of FIG. 5A in a connected state.

FIG. 6A illustrates a perspective view of another embodiment of an adapter including generally identical sections that are hingingly attached via a side wall thereof.

FIG. 6B illustrates a front view of the adapter of FIG. 6A in an open state.

FIG. 6C illustrates a perspective view of the adapter of FIG. 6A in a closed state.

FIG. 7A illustrates a perspective view of another embodiment of an adapter including generally identical sections that are attached at a front end thereof in an open state.

FIG. 7B illustrates the adapter of FIG. 7A with a syringe loaded therein.

FIG. 7C illustrates the adapter of FIG. 7A wherein the sections thereof have been hingingly closed for connection of the adapter to an injector.

FIG. 8A illustrates a perspective view of a portion of an injector having at least one removable face plate for attachment of a syringe or an adapter thereto.

FIG. 8B illustrates a perspective view of an embodiment of an adapter for use with the injector of FIG. 8A.

FIG. 8C illustrates a perspective view of another embodiment of an adapter for use with the injector of FIG. 8A.

FIG. 8D illustrates a perspective view of another embodiment of an adapter for use with the injector of FIG. 8A.

FIG. 8E illustrates a perspective view of another embodiment of an adapter for use with the injector of FIG. 8A.

FIG. 9A illustrates a perspective view of an embodiment of an adapter assembly or system in which a push rod performs the function of a syringe plunger extension rod.

FIG. 9B illustrates a perspective view of the adapter assembly of FIG. 9A in a disconnected state.

FIG. 9C illustrates a cross-sectional view of the adapter assembly of FIG. 9A.

FIG. 10A illustrates a perspective view of an embodiment of an adapter assembly or system in which the carrier section hinges with respect to the intermediate section to allow removal of the syringe after an injection procedure without retraction of the injector drive member.

FIG. 10B illustrates an expanded perspective view of the forward portion of the carrier section.

FIG. 10C illustrates a perspective view of an embodiment of a syringe retainer for use in the adapter system.

FIG. 10D illustrates a front cross-sectional view of the syringe retainer of FIG. 10C.

FIG. 11 illustrates a perspective view of an adapter system in which the push rod hinges to allow removal of the syringe after an injection procedure without retraction of the injector drive member.

FIG. 12A illustrates a perspective view of an embodiment of an adapter assembly in a disconnected state including a contact or sealing member for removing injection fluids from a push rod.

FIG. 12B illustrates a perspective view of the adapter assembly similar to the adapter assembly of FIG. 12A in a connected state.

FIG. 13A illustrates a perspective view of an embodiment of an adapter assembly including a biasing member to bias the syringe forward within the carrier section.

FIG. 13B illustrates a perspective view of the adapter assembly of FIG. 13A in a disconnected state.

FIG. 14 illustrates a perspective view of another embodiment of a biasing member to bias the syringe forward within the carrier section.

DETAILED DESCRIPTION OF THE INVENTION

An embodiment of a front-loading injector system **5** of the present invention is illustrated in FIGS. 1A and 1B. Injector system **5** is particularly adapted for use in MRI procedures and includes a powered injector **10**, a syringe **20** for injection of saline solution and an adapter **100**. An example of an injector **10** suitable for use in the present invention is the SPECTRIS® injector available from Medrad, Inc. of Indianola, Penn. However, the present invention may be used in connection with other fluid delivery systems, including injectors and infusion pumps for computed tomography, ultrasound and angiographic procedures. As best illustrated in FIG. 1B, injector housing **30** of injector **10** preferably includes a first drive member or piston **40** therein which cooperates with a syringe plunger **50** in saline syringe **20** to inject a saline solution from the interior of syringe **20** into a patient.

As shown in FIGS. 1B, injector 10 also includes a second drive member or piston 40' that cooperates with an adapter 100 and a syringe plunger extension rod 220 of a syringe 200 (see, for example, FIG. 2A) containing a fluid such as a contrast medium to inject the fluid from the interior of syringe 200 into a patient.

As used herein to describe injection system 5 and other embodiments of the present invention, the terms "axial" or "axially" refer generally to, for example, an axis A around which adapter 100 is preferably formed (although not necessarily symmetrically therearound) or an axis B around which saline syringe 20 is formed (although not necessarily symmetrically therearound). The terms "proximal" or "rearward" refer generally to an axial or a longitudinal direction toward the end of injector housing 30 opposite the end to which syringe 20 and adapter 100 are mounted. The terms "distal" or "forward" refer generally to an axial or a longitudinal direction toward a syringe tip of syringe 20 or syringe 200. The term "radial" refers generally to a direction normal to an axis such as axis A or axis B.

Saline syringe 20 and adapter 100 are preferably removably connected to injector 10 as described in U.S. Pat. No. 5,383,858. In that regard, front-loading injector 10 preferably includes a front wall 60 having a first opening 62 formed therein. Piston 40 is reciprocally mounted within injector 10 and is extendible through opening 62. Piston 40 preferably includes a piston flange or head 44. Receiving slots 66a and 66b, are preferably positioned opposite one another around opening 62. Receiving flanges 68a and 68b are preferably positioned opposite one another and between receiving slots 66a and 66b and extend inwardly into opening 62.

The rearward end of saline syringe 20 preferably includes a readily releasable mounting mechanism such as a pair of mounting flanges 22a and 22b for mounting saline syringe 20 in a desired position relative to the front wall 60 of injector 10. Flange 22b is not shown but is generally identical to flange 22a and positioned opposite flange 22a. Mounting flanges 22a and 22b may include indicating means, such as detent(s), bar code(s), protrusion(s) or notch(es) 24a, which provide information to the injector 10, for example, about the type of saline syringe 20 being used. Correspondingly, injector 10 preferably includes any suitable means (not shown) for reading information from notch(es) 24a.

To attach syringe 20 to injector 10, the rearward end of syringe 20 is inserted into injector opening 62 such that mounting flanges 22a and 22b are inserted into receiving slots 66a and 66b, respectively. If, at this time, plunger 40 is not positioned at the rearward end of syringe 20 such that a piston flange 44 can engage capture members 54 (as described in U.S. Pat. No. 5,383,858), piston 40 may be advanced forward by the operation of injector 10 until piston flange 44 is in position to be received by capture members 54.

Once mounting flanges 22a and 22b are inserted into receiving slots 66a and 66b, respectively, and piston 40 is in position to be received by capture members 54, the operator preferably rotates syringe 20 approximately 90 degrees such that mounting flanges 22a and 22b move behind and are engaged by receiving flanges 68a and 68b, respectively, and piston flange 44 rotates into position to be retained by, for example, L-shaped capture members 54. Injector 10 may include a stop mechanism (not shown), for example, extending from at least one of the retaining slots 68a and 68b, to prevent rotation of syringe 20 more than 90 degrees. Tactile,

visual or audible feedback can be provided to the operator via, for example, cooperating members on syringe 20 and injector 10 to inform the operator that secure connection has been achieved. After securely attaching syringe 20 to injector 10, advancing piston 40 in a forward direction will apply a motive force to plunger 50 to advance plunger 50 forward within syringe 20, thereby forcing saline solution in syringe 20 out of syringe neck 26 into the fluid path to the patient. Retracting piston 40 in a rearward direction will cause plunger 50 to move rearward in syringe 20, thereby drawing fluid into syringe 20.

Adapter 100 is preferably attached to injector 10 in a similar manner as described above for attachment of syringe 20 to injector 10. In that regard, a rearward portion or section of adapter 100 preferably includes a readily releasable mounting mechanism such as a pair of mounting flanges 102a and 102b (see FIG. 2A) for mounting adapter 100 in a desired position relative to the front wall 60 of injector 10. Mounting flanges 102a and 102b may include indicating means, such as detents or notches 104a and 104b, which provide information to injector 10 about the type of adapter and/or syringe being used. Correspondingly, injector 10 preferably includes any suitable means (not shown) for reading information from notches 104a and 104b.

To attach adapter 100 to injector 10, the rearward end of adapter 100 is inserted into injector opening 62' such that mounting flanges 102a and 102b are inserted into receiving slots 66a' and 66b', respectively. Once mounting flanges 102a and 102b are inserted into receiving slots 66a' and 66b', respectively, the operator preferably rotates adapter 100 or adapter 100/syringe 200 combination approximately 90 degrees such that mounting flanges 102a and 102b move behind and are engaged by receiving flanges 68a' and 68b', respectively. As described above, a stop mechanism (not shown) may, for example, extend from at least one of the retaining slots 68a' and 68b', to prevent rotation of adapter 100 more than 90 degrees. Once again, tactile, visual or audible feedback can be provided to the operator via, for example, cooperating members on adapter 100 and injector 10 to inform the operator that secure connection has been achieved. A drip flange 106 can, for example, be formed on a rearward portion of adapter 100 to, among other things, assist in forming a secure connection. Drip flange 106 may, for example, include a raised member or detent 108 (see, for example, FIG. 2A) that mates with a recess (not shown) in the face of opening 62' to provide audible and/or tactile feedback to the operator upon proper alignment/connection of adapter 100 to injector 10.

After securely attaching adapter 100 to injector 10, advancing piston 40' in a forward direction will apply a motive force to a plunger extension 220 of syringe 200 to advance syringe plunger 225 (see FIG. 2E) forward within syringe barrel 210, thereby forcing contrast medium in syringe 200 out of syringe neck 250 into the fluid path to the patient.

Adapter 100 is illustrated in further detail in FIGS. 2A through 2E. In the embodiment of adapter 100, a "break" action is used to load syringe 200 into a carrier 110 of adapter 100. In that regard, carrier 110 includes a first portion or section 120 and a second portion or section 130. First portion 120 is hingingly attached to second portion 130 via support arms 132a and 132b, each of which includes a passage 134 therein. First portion 120 includes generally cylindrical tabs 122 on each side thereof that snap into passages 134 to hingingly or rotatably attach first portion 120 to second portion 130 about an axis C (see, for example, FIG. 2D) preferably oriented generally perpendicular to longitudinal axis A of adapter 100.

FIG. 2A illustrates adapter **100** in an open state and ready to receive syringe **200** from a position to the rear of the hinging mechanism. In this embodiment, syringe **200** comprises generally cylindrical body or barrel **210** in which a fluid such as contrast medium, saline or therapeutic agent is contained. Preferably, the fluid medium is “prefilled” into syringe **200** before loading of syringe **200** in adapter **100**. Syringe **200** can, for example, be prefilled by the manufacturer or manually filled remote from the injector. Syringe **200** further includes plunger **225** slideably disposed within barrel **210** that is similar in operation to plunger **50** of saline syringe **20**. Plunger **225** of syringe **200** is operatively connected to plunger extension rod **220** by, for example, a threaded connection. Syringe **200** further includes a flange **230** at a rearward end of barrel **210**. At a forward end of barrel **210**, syringe **200** includes, for example, a generally frusto-conical transition or cone region **240** that connects barrel **210** to a tapered neck **250** from which contrast medium is injected. Tapered neck **250** can include, for example, a luer connection at the end thereof for connection to a fluid path (for example, flexible tubing) as known in the art.

In many cases, syringes **200** for use, for example, in an MRI procedure are prefilled with contrast medium by the manufacturer. Many such syringes **200** are designed for manual injection into a patient wherein an operator manually advances plunger rod **220** (and thereby plunger **225** within syringe **200**) forward by applying pressure to a rearward end **228** of plunger extension rod **220**. Syringe barrel **210** and flange **230** may, for example, be fabricated from glass or plastic. Plunger extension rod **220** is typically fabricated from a plastic material.

As illustrated in FIGS. 2A and 2B, syringe **200** is loaded into carrier **110** by positioning syringe **200** in general alignment with a generally cylindrical passage **140** formed in a forward end of first portion **120** of adapter **100**. Syringe **200** is slid forward within passage **140** until syringe flange **230** abuts a shoulder **150** (see FIG. 2E) that extends radially inwardly within first portion **120**. Shoulder **150** cooperates with syringe flange **230** to hold syringe **200** within adapter **100** and to provide resistance to the forward force applied to plunger extension rod **220** by piston **40'** during an injection procedure.

As best illustrated in FIG. 2E, shoulder **150** preferably includes a rearward extending ridge portion **154** on the inner radius thereof so that ridge portion **154** contacts flange **230** only near or in the vicinity of the transition of syringe flange **230** into syringe barrel **210**. Contact of ridge portion **154** with syringe flange **230** near barrel **210** assists in minimizing the forces placed upon cantilevered flange **230**. For example, in the case of glass syringes **200**, flange **230** may fail (break) if contact with shoulder **150** is made at or near the outer end of syringe flange **230**, whereas the shorter lever arm resulting from contact with syringe flange **230** at or near the inner radius thereof will reduce the force on syringe flange **230** and prevent failure. Ridge portion **154** can be made of a resilient or compliant material such as an elastomeric material that can be different from the material of the remainder of adapter **100** to further reduce the likelihood of failure.

In the case of a prefilled syringe **200**, there is no need for the operator to retract the plunger of syringe **200** to load syringe **200** with contrast medium. Therefore, there is usually no need for a follower mechanism in the adapter of the present invention to attach to plunger extension rod **220** to enable retraction of plunger **225** as described in connection with the adapter of U.S. Pat. No. 5,520,653. Piston **40'** can simply be advanced to abut rearward surface **228** of plunger

extension rod **220**. Any further forward motion of piston **40'** will result in advancement of the plunger of syringe **200** and pressurization of the contrast medium with syringe **200**. Elimination of a carrier mechanism for the plunger extension simplifies and reduces the cost of manufacture of the adapters of the present invention as compared, for example, to the adapter of U.S. Pat. No. 5,520,653. Nevertheless, the adapters of the present invention may readily be configured with follower mechanisms that connect to plunger extension rods **220** to allow plunger retraction.

FIGS. 2C through 2E illustrate syringe **200** within adapter **100** with first portion **120** and second portion **130** in a closed position. Adapter **100** preferably includes a mechanism to assist in maintaining first portion **120** and second portion **130** in a closed position during operation of injector **100**. Second portion **130** may, for example, include a latch tab **136** having an abutment shoulder **138** that cooperates with a recess **128** in a rearward end of first portion **120** to create a snap latching mechanism. Many other closing mechanisms can be used to maintain first portion **120** and second portion **130** in a closed position, as clear to one skilled in the art.

Closed carrier **110** created by first portion **120** and second portion **130** also functions to limit the motion of plunger extension rod **220** out of alignment with axis A. This prevents plunger extension rod **220** from, for example, slipping out of contact with piston **40'**, prevents deforming of plunger extension rod **220** and prevents eccentric loading of plunger extension rod **220**. Deflection, eccentric loading or deforming of plunger extension rod **220** may, for example, cause leaking of fluid to the rear of plunger **225** or breaking of syringe **200**. Radially inward projecting guide(s) can be formed in one or both of first portion **120** and second portion **130** to maintain even tighter tolerances. A section of either or both of first portion **120** and second portion **130** can be “cut away” to form a window for viewing of syringe extension rod **220**. Likewise, a portion or the entirety of either or both first portion **120** and second portion **130** can be transparent.

Preferably, one or both of first portion **120** and second portion **130** includes an abutment member to prevent rotation of syringe **200** within carrier **110**. It is, for example, desirable to prevent rotation of syringe **200** after connection thereof to fluid path tubing. Prevention of syringe rotation can also maintain syringe **200** in proper orientation for viewing, for example, volume gradations on syringe **200**. One or more sides of first portion **120** can, for example, have a flattened profile to conform to flattened section(s) **234** of syringe flange **230** to prevent rotation of syringe **200**.

As illustrated in FIGS. 2B through 2E, a substantial portion of syringe **200** extends forward through passage **140** so that syringe barrel **210** is plainly visible to the operator. Such visibility, for example, facilitates reading of wording printed on the syringe as well as visual determination of the volume of contrast remaining in syringe **200**. Visibility of syringe **220** also allows the operator to more readily determine whether air is present in syringe **200** before commencing an injection procedure. Moreover, operators typically like to see plunger **225** in motion to provide reassurance that the injection is proceeding. Extension of a portion of syringe **200** beyond carrier **110** also facilitates grasping of syringe **200** by the operator to, for example, connect or disconnect a fluid path to syringe neck **250**.

As illustrated, for example, in FIGS. 2A through 2C, axis C of rotation of the hinge mechanism (that is, the axis passing through the radial center of generally cylindrical tabs **122** in the embodiment of FIG. 2A) is preferably

positioned such that the force experienced by carrier **110** during forward advancement of piston **40'** tends to force or maintain carrier **100** in a closed position. The axis of cylindrical tabs **122** is preferably, for example, positioned above the center line or longitudinal axis of carrier **110** such that a forward force exerted on shoulder **150** tends to produce a torque that maintains first portion **120** in a latched, closed position relative to second portion **130**.

Once an injection procedure is completed, the operator can grasp the adapter or adapter/syringe combination and rotate it 90 degrees back to the preinstallation orientation, thereby, disengaging mounting flanges **102a** and **102b** from behind receiving flanges **68a** and **68b**, respectively. The adapter/syringe combination is then removable from the injector **10**.

Retaining syringe **200** within carrier **110** by abutment with shoulder **150**, allows accommodation of many different designs of syringe **200** by carrier **110**. Adapter **100** is thus usable with a wide variety of currently available syringes **200**.

FIGS. **3A** through **3E** illustrate another embodiment of an adapter **300** for use with a syringe **200**. The rearward portion of adapter **300** is essentially identical to that of adapter **100** and is removably attached to injector **10** as described above. Unlike adapter **100**, which holds syringe **200** within adapter **100** and provides resistance to the forward force applied to plunger extension rod **220** by abutment of syringe flange **230**, syringe **200** is held within adapter **300** and resistance provided to the forward force applied to plunger extension rod **220** by abutting a forward facing surface of forward transition region **240** of syringe **200** rather than by abutting or retaining syringe flange **230**.

Like adapter **200**, a hinging or "break" action is used to load syringe **200** into a carrier **310** of adapter **300**. In that regard, carrier **310** includes a first portion **320** and a second portion **330**. First portion **320** is hingingly or rotatably attached to second portion **330** via support arms **332a** and **332b**, each of which includes a passage **334** therein. First portion **320** includes generally cylindrical tabs **322** on each side thereof that reside in passages **334** to hingingly attach first portion **320** to second portion **330**. First portion **320** rotates about an axis C that runs generally through the radial centers of tabs **322** and is generally perpendicular to the longitudinal axis A of adapter **300**.

FIG. **3A** illustrates adapter **300** in an open state and ready to receive syringe **200**. As illustrated in FIGS. **3A** and **3B**, syringe **200** is loaded into carrier **310** by positioning syringe **200** in general alignment with a generally cylindrical passage **340** formed in first portion **320** of adapter **300**. Syringe **200** is slid forward within passage **340** until a forward facing surface of syringe **200** abuts a retention shoulder **350** (see FIG. **3E**) that extends radially inward at a forward end of a forward portion **342** of first portion **310**. Shoulder **350** cooperates with forward syringe transition region or cone **240** to hold syringe **200** within adapter **300** and to provide resistance to the forward force applied to plunger extension rod **220** by piston **40'** during an injection procedure. As illustrated in detail D of FIG. **3E**, shoulder **350** preferably contacts syringe **200** only near to or in the vicinity of the transition from the sidewall of barrel **110** to transition region **240** to take advantage of increased structural strength in this region. The contact area of shoulder **350** can be made of a resilient or compliant material (for example, an elastomeric material) to absorb energy and reduce the likelihood of breaking syringe **200**.

Syringe **200** may be inserted in adapter **300** before connection of adapter **300** to injector **10**. Alternatively,

syringe **200** may be loaded into adapter **300** while adapter **300** is mounted on injector **10**. Indeed, adapter **300** may remain mounted on injector **10** through many different injection procedures with different syringes.

Forward portion **342** preferably includes one or more open areas or windows **344** so that syringe barrel **210** is plainly visible to the operator. All or a portion of forward portion **342** can also be transparent to further facilitate viewing of syringe barrel **210**. Open areas **344** also facilitate grasping of syringe **200** by the operator to, for example, connect or disconnect a fluid path to syringe neck **250**. As described in connection with adapter **100**, one or both of first portion **320** and second portion **330** may include an abutment member to prevent rotation of syringe **200** within carrier **310**. For example, the side(s) of first portion **320** can have a flattened profile to conform to flattened section(s) **234** of syringe flange **230** to prevent rotation of syringe **200**. The cooperation of such a flattened profile of carrier **310** and section **234** can, for example, be used to ensure a desired orientation of syringe barrel **210** with open areas **344**. For example, two open areas **344** can be provided generally opposing each other (that is, positioned approximately 180° apart on forward portion **342**). The cooperation of a flattened profile of carrier **310** and flattened syringe flange section **234** in this embodiment preferably allows mounting of syringe **200** in carrier **310** in only two axially rotated orientations, 180° apart.

One or a plurality of inward projecting guide **360** can be formed in one or both of first portion **120** and second portion **130** to maintain tight tolerances to prevent deflection of plunger extension rod **330** as discussed above. A plurality (for example, three) guides **360** can be used about first portion **120** and/or second portion **130** to limit or prevent deflection in any direction.

Open areas (not shown) can also be provided on carrier **310** in the area where syringe flange **230** resides to accommodate large (in a radial direction) or irregularly shaped syringe flanges **230**. Such open areas preferably extend longitudinally to accommodate syringes of different length from a forward end thereof to the syringe flange thereof. In general, the adapters of the present invention preferably provide adequate capacity to accommodate syringes of widely varying length, diameter etc.

An important function of an injector is to monitor and report the actual volume of fluid available for delivery within a syringe. This function, for example, enables rapid decision on whether enough fluid is present to proceed with an imaging procedure or whether additional volume should be loaded. Monitoring the cumulative volume of fluid delivered to a patient is also desirable for certain applications where a recommended per-patient dosage volume should not be exceeded. Fluid volumes delivered by injectors are typically displayed in 1.0 ml increments and are tracked by the injector with finer resolution than is displayed. Injectors also preferably detect and differentiate among different types and sizes of syringes so that accurate display and delivery of fluid volume is provided.

To achieve such fluid volume management specifications, an adapter or syringe must be installed on an injector, be oriented in a known manner and provide the control system with identification information. Identification can be provided by coded features on the adapter or syringe that are detected by sensors on the injector so that each adapter and/or syringe is known by its code and fluid volume parameters specific to that syringe are implemented. When syringes **200** that are intended for non-powered, hand injec-

tion are installed on power injector **10**, adequate identification is still preferably provided. This result can be achieved by first placing syringe **200** in adapter **100** or **300** which facilitates mounting on injector **10** and possesses its own unique code as encoded by, for example, the positions of notches **104a** and **104b**. In this manner, many different types and sizes of syringes **200** and/or adapters can be accommodated.

Syringes **200** are frequently of similar geometry such that more than one type of syringe **200** can be carried by the same adapter, giving rise to the potential of incorrect identification and possible fluid delivery error by injector **10**. However, it is desirable to minimize the number of adapters required to accommodate all the hand syringes intended for a specific injector leading to a need to install more than one volume of syringe per adapter, provided individual functionality can be achieved. Syringes that share the same functional internal diameter, but have different lengths of travel can be treated as equivalent if both are referenced to the adapter, and consequently to injector **10**, by a front-most surface thereof (that is, cone or transition region **240**). If syringes **200** sharing the same functional diameter but having different lengths are referenced to the adapter injector **10** by rear flange **230** only, injector **10** will not be able to determine where the front of a syringe **200** is and cannot accurately determine/report the volume of contrast medium available. Mounting hand syringes **200** by rear flange **230** as in the embodiment of adapter **100** thus preferably requires one adapter per syringe diameter and length combination, which results in a larger number of adapters than would be required using a front mounting as in the embodiment of adapter **300**. Multiple adapter combinations decrease the ease of use for an operator and expand the logic and sensing capacity required of injector **10**. An optimum approach would be to use a single adapter that accommodates all hand syringes targeted for a particular injector. To approach this goal, it is preferable to retain/about a front end of syringes **200** as described above in connection with adapter **300** so that injector **10** can determine the position of the front end of syringe **200**. Loading of a front end of syringe **200** is also preferred to take advantage of an area of increased syringe strength to prevent syringe failure.

FIGS. **4A** through **4C** illustrate another embodiment of an adapter **400** for use with syringe **200**. The rearward portion of adapter **400** is essentially identical to that of adapters **100** and **300** and is removably attached to injector **10** as described above. Unlike adapters **100** and **300**, which incorporate a hinging action to enclose syringe **200**, syringe **400** includes an open carrier **410**. Like adapter **300**, however, syringe **200** is held within adapter **400** and resistance provided to the forward force applied to plunger extension rod **220** by abutting forward transition or cone region **240** of syringe **200**.

As illustrated in FIGS. **4A** and **4B**, syringe **200** is simply loaded into adapter **400** by dropping syringe **200** therein from above. Adapter **400** preferably includes a first, rearward portion **420** that seats/supports syringe flange **230**. Preferably, first portion **420** has generally flat side walls **422** that cooperate with generally flat sections **234** on syringe flange **230** to restrict or substantially prevent rotation of syringe **200** within adapter **400**. Side walls **422** of first portion **420** preferably extend upward past the generally common axis of syringe **200** and adapter **400** to assist in supporting syringe **200**.

Adapter **400** further includes a second, forward portion **430** that seats/supports syringe barrel **210**. Second portion **430** preferably includes a radially inward extending abut-

ment shoulder **450** that abuts cone or transition region **340** of syringe **200** to retain syringe **200** within adapter **400** and provide resistance to the forward force applied to plunger extension rod **220** by piston **40'**. Although second portion **430**, including abutment shoulder **450**, are open on the top thereof, the generally cylindrical wall of second portion **430** and abutment shoulder **450** can extend upward past the generally common axis of syringe **200** and adapter **400** to support resistance of the forward force applied to plunger extension rod **220** and to prevent deflection of syringe **200** out of alignment with the shared axis of syringe **200** and adapter **400**.

Through abutment shoulder **450**, adapter **400** provides the benefits of forward abutment of syringe **200** discussed above. Moreover, because adapter **400** is open along its entire axial length, insertion and removal of syringe **200** is facilitated. For example, syringe **200** can even be easily removed from adapter **400** while still connected to a fluid path (not shown in FIGS. **4A** through **4C**). In some cases, however, it may be desirable to form abutment shoulder **450** to contact a forward facing surface of transition region **240** around its entire circumference to provide additional stability. In that case, the forwardmost end of carrier **410** would be closed and any fluid path would preferably be disconnected before removing syringe **200** from adapter carrier **410**.

Adapter **400** preferably further includes at least one retaining member **460** to assist in retaining and/or stabilizing syringe **200** in proper alignment therein. Retaining member **460** is slideably retained in a generally cylindrically shaped passage **470** in carrier **410**. Retaining member **460** is illustrated in an open or disengaged position in FIGS. **4A** and **4B**. To close or engage retaining member **450** to retain syringe **200**, the operator can supply force to collar tab **462** to rotate retaining member **450** within passage **470** to a closed position as illustrated in FIG. **4C**. In another embodiment illustrated in FIG. **4D**, rotatable retaining member **460** can be split into two portions **460'** and **460''** that rotate to meet in the middle.

Other retaining/stabilizing members or mechanisms for retaining/stabilizing syringe **200** are illustrated in FIGS. **4E** through **4I**. In FIG. **4E** a sliding retaining member **460a** is positioned on/around second, forward portion **430** of carrier **410**. Retaining member **460a** is preferably positioned at a forwardmost position on second portion **430** when syringe is loaded into carrier **410** to facilitate loading. Retaining member **460a** is retained on second portion **430** by abutment with a forward shoulder **480** and rearward shoulder **482**. After seating of syringe **200**, retaining member **450a** can preferably be slid to any desired position on second portion. Positioning retaining member **460a** at a rearwardmost position on second portion **430** may maximize stability. Retaining member **460a** preferably conforms closely to the shape of syringe barrel **210** to maximize stability. Retaining member **460a** may include an open section **462a** on the top thereof to facilitate removal of syringe **200** from carrier **410** without disconnection of an attached fluid path element.

FIG. **4F** illustrates another embodiment of a slideable retaining member **460b**. Retaining member **460b** is slideably retained upon first portion **420** of carrier **410** between drip flange **106** and shoulder **484**. To facilitate loading of syringe **200**, retaining member **450b** may be positioned near drip flange **106**. After loading of syringe **200**, retaining member **460b** can be slid to a desired position. An opening (not shown) in retaining member **460b** can be formed to facilitate removal of syringe **200** from carrier **410** without disconnection of an attached fluid path element.

In the embodiment of FIG. 4G, a retaining mechanism includes two cantilevered retaining member **460c'** and **460c''** that snap around syringe barrel **210** upon loading of syringe **200** in carrier **410**.

A plurality of retaining/stabilizing members as described above can be provided along the length of carrier **410** to assist in retaining/stabilizing syringe barrel **210** and plunger extension rod **420** in proper position within carrier **410**. The opening and closing of such retaining members can be operated individually or collectively, for example, via a common tab.

Alternatively, a retaining/stabilizing member can be increased in axially length to increase stability. For example, FIG. 4H illustrates a retaining member **460d** hingingly attached to first portion **420** that extends along the entire length of first portion **420** and partially along the length of second portion **430** when closed. A similar retaining member can alternatively or additionally be hingingly attached to second portion **430**. As an alternative to a hinging motion, such retaining member can rotate in a passage or slot formed in carrier **410**.

An example of a widened, rotating retaining member **460e** is illustrated in FIG. 4I. Retaining member **460e** is rotatably attached (about the longitudinal axis of carrier **410**) to second portion **430** and extends generally along the entire length of second portion **430**. After syringe **200** is top loaded into carrier **420**, retaining member **460e** can be rotated to form a cover over second section **430**. Retaining members **460d** and **460e** can be transparent or formed with cut away sections to enhance the visibility of syringe **200**.

In some cases it may be desirable to manufacture the adapter of the present invention to be disposable after one or more uses. Such disposable adapters are preferably manufactured in an inexpensive manner. In FIGS. 5A and 5B, an embodiment of a preferably disposable adapter **500** is illustrated. Adapter **500** preferably includes two generally identical members **510a** and **510b**. Fabricating adapter **500** from two generally identical members **510a** and **510b** may substantially reduce manufacturing costs. Members **510a** and **510b** may for example be fabricated to "snap" together (for example, via extension members **520** and cooperating catch members **530**) and provide visible, audible and/or tactile feedback to indicated proper connection.

In use, syringe **200** is preferably seated in one of members **510a** or **510b**. The other portion is then, for example, snapped into place to encompass syringe **200** within the resultant adapter **500** (see FIG. 5B). When assembled, portions **510a** and **510b** form a rearward section that houses plunger extension rod **220** and a forward portion that houses syringe barrel **210**. At or near a rearward end of adapter **500**, members **510a** and **510b** preferably form a connecting section including first mounting flange **502a** and a second mounting flange **502b** adapted to removably attach adapter **500** to injector **10** as described above. As illustrated in FIG. 5b, adapter **500** encompasses both syringe barrel **210** and plunger extension rod **220** to retain/stabilize syringe **200**. The side walls of adapter **500** can be formed with a generally flat or flattened profile to interact with/about generally flat section(s) **234** of syringe flange **230** to prevent rotation of syringe **200** about its axis within adapter **200**.

To facilitate viewing of either plunger extension rod **220** or barrel **210**, adapter **500** can be formed with cut out window sections **540**. Moreover, any portion or all of adapter **500** can be transparent.

Adapter **500** provides resistance to the forward force applied to plunger extension rod **220** by abutment of syringe

transition region **240** with a radially inward extending shoulder section **550**. The advantages of providing such resistance/retention by abutment of syringe transition region **240** discussed above in connection with other embodiments of adapter of the present invention are also provided by adapter **500**.

Another embodiment of an adapter **500'** is illustrated in FIGS. 6A through 6C. Adapter **500'** is generally identical to adapter **500** except that adapter **500'** is formed from the connection of a first portion **510a'** and a second portion **510b'** that are initially hinged together, for example by a notched plastic hinge **512** as known in the art) as best illustrated in FIGS. 6A and 6B.

FIGS. 7A through 7C illustrate another embodiment of an adapter **600** of the present invention. Adapter **600** includes a first member **610a** and a second member **610b** that are attached via a forward hinge mechanism. The hinge mechanism preferably includes a generally cylindrical member **612** on an extending member **614** of one of first member **610a** and second **610b** that is rotatably seatable in a passage **616** formed in an extending member of the other of first member **610a** and second member **610b**. Extending members **614** preferably extend forward on each side of a forward end of each of first member **610a** and second member **610b** as illustrated in FIG. 7A.

First member **610a** includes first retaining flange **102a** as described above, while second member **610b** includes second retaining flange **102b** that operate to connect adapter **600** to injector **10** as described above. First member **610a** preferably includes one half of a drip flange **106a**, while second member **610b** preferably includes the other half of a drip flange **106b**.

To seat syringe **200** within adapter **600**, first member **610a** and second member **610b** are preferably rotated about an axis C' of hinging mechanism (which axis is generally perpendicular to the orientation of longitudinal axis A' of adapter **600**) to an open position as illustrated in FIGS. 6A and 6B. Barrel **210** of syringe **200** is then passed through an opening **640** formed at the forward end of adapter **600**. Syringe **200** is advanced forward through passage **640** until flange **230** abuts radially inward extending shoulder **650** to retain syringe **200** within adapter **600** and provide resistance to forward force exerted upon plunger extension rod **220** by piston **40'**. First member **610a** and second member **610b** are then rotated to a closed position. As discussed above in connection with adapter **100**, shoulder **650** may include a raised (rearward extending) abutment ridge **660** to ensure that contact is made with syringe flange **230** near the point where syringe flange **230** is connected to barrel **210**. Forward force exerted upon shoulder **650** assists in maintaining adapter **600** in a closed position as illustrated in FIG. 6C.

Like adapters **500** and **500'**, first member **610a** and second member **610b** can be formed to be generally identical. Fabrications costs of adapter **600** can thereby be reduced.

In all of the embodiment discussed above, the adapter is attached to injector **10** via mounting flanges on a rearward portion or section of the adapter. There are, however, alternative manners in which an adapter of the present invention may be attached to injector **10**. As illustrated in FIG. 8A, for example, an injector may include a front wall **700** to which at least one removable face plate **705** is attached. The injector of FIG. 8A is designed for use in an MRI procedure and includes a first, contrast syringe **710** attached to a first face plate **705** and a second, saline syringe **720** attached to a second face plate **705'**. In the embodiment of FIG. 8A, face plate **705** is rotated upward to be detached from the injector.

FIG. 8B illustrates an embodiment of an adapter **800** including a carrier **810** formed integrally or attached to a face plate **805** suitable for attachment to the injector of FIG. 8A. Syringe **200** can be “breach” loaded into carrier **810** by first tilting syringe **200** and advancing barrel **210** of syringe **200** in a forward direction through passage **840** formed in a forward most position of an enclosed forward section **830** of carrier **810**. Syringe **200** is advanced until syringe cone region **240** abuts radially inwardly extending shoulder **850** that defines passage **840**. Face plate **805** includes a passage **808** therein through which a piston (not shown) of the injector of FIG. 8A can pass to cooperate with plunger extension rod **220**.

FIG. 8C illustrates an embodiment of an adapter **900** that includes a carrier **910** attached to a removable face plate **905**. In this embodiment, syringe **200** is advanced through passage **908** in face plate **902**. Syringe **200** is advanced forward until cone region **240** abuts radially inward extending shoulder **950** of carrier **910**.

FIG. 8D illustrates an embodiment of an adapter **1000** that includes a carrier **1010** attached to a removable face plate **1005**. Syringe **200** is loaded into carrier **1010** from the top by dropping syringe **200** into carrier **1010**. When seated in carrier **1010**, syringe **200** abuts radially inward extending shoulder **1050** of carrier **1010**. The top of carrier **1010** is maintained in an open state over the length of carrier **1010** to facilitate removal of syringe **200** even when connected to a fluid path element.

FIG. 8E illustrates an embodiment of an adapter **1100** that includes a carrier **1110** attached to a removable face plate **1105**. Like adapter **1010**, syringe **200** is loaded into carrier **1110** from the top by dropping syringe **200** into carrier **1110**. When seated in carrier **1110**, syringe transition region **240** abuts radially inward extending shoulder **1150** of carrier **1110**. Carrier **1110** includes a hinging cover section **1160** that can be rotated to a closed position to form a cover/retainer over at least a portion of syringe barrel **210** to assist in retaining/stabilizing syringe **200**. Shoulder **1050** can be rotatable to capture syringe **200** and support it.

FIGS. 9A through 9C illustrate an embodiment of an adapter system **1200** including a carrier section **1210**, an intermediate section **1220**, and a rearwardmost connecting section **1230**. Adapter **1200** further includes a push rod **1240**. Syringe **200** is seated in carrier section **1210** by dropping syringe **200** into carrier section **1210**. Cone region **240** abuts shoulder **1250** of carrier section **1210**. The plunger extension rod (not shown) has been removed from connection with syringe plunger **225**. In many cases, such plunger extension rods are connected to plunger **225** via threading on the forward end of the plunger extension rod.

Push rod **1240** extends through intermediate section **1220** to cooperate with plunger **225** to apply force to plunger **225**. In the case of a prefilled syringe, there is typically no need to retract plunger **225** within syringe **200**. In such cases, there is no need to establish an engaging connection (threaded or otherwise) between a forward end of push rod **1240** and plunger **225** to resist the force of and couple plunger **225** to push rod **1240** during a retracting motion of push rod **1240**. This greatly simplifies the construction and operation of push rod **1240** and the injector.

In operation of adapter system **1200**, push rod **1240** makes a connection with a piston (not shown in FIGS. 9A through 9C; see FIG. 1A) of the injector through a connective coupling **1242** on a rearward end of push rod **1240**. Connecting section **1230** is removably attached to the injector via the cooperation of mounting flanged **1202a** and **1202b**

and drip flange **1206** with the injector as described above. Syringe **200** can be top loaded into carriage section **1210** either before or after connection of adapter **1205** to the injector via connecting section **1230**. Push rod **1240** is advanced forward through intermediate section **1220** by the injector piston until forward end **1244** pilots into syringe plunger **225** to abut a rearward facing wall section within plunger **225**. Once again, no secured connection to resist a rearward motion need be effected between push rod forward end **1244** and plunger **225** in, for example, the case of a prefilled syringe or in any other case that retraction of plunger **225** within syringe **200** will not be required. Push rod forward end **1244** is preferably of generally the shape of the rearward facing interior of plunger **225**. In this manner, push rod forward end **1244** provides support to plunger **225** to maintain the shape of plunger **225** during use of syringe **200**. In many cases, plunger **225** will be fabricated predominantly from an elastomeric cover material. If the side walls of plunger **225** do not make adequate sealing contact with the interior side wall of syringe barrel **210**, leakage of contrast to the rear of plunger **225** can occur during advancement of plunger **225**.

FIGS. 10A through 10D illustrate another embodiment of an adapter system **1300** of the present invention. Similar to adapter system **1200**, adapter system **1300** includes a carrier section **1310**, an intermediate section **1320**, and a rearwardmost connecting section **1330**. Adapter system **1300** further includes or operates with a push rod **1340**. Syringe **200** is seated in open carrier section **1310** by placing syringe **200** into carrier section **1310** from above (and can be seated therein or removed therefrom without removal or any attached tubing). Forward transition or cone region **240** abuts a shoulder portion **1350** of carrier section **1310**.

To minimize fabrication costs of adapter system **1300**, it is desirable that the option of using, for example, less expensive, lower-strength polymeric materials be available. Because the top portion of carrier section **1310** and shoulder **1350** are open for ease of removal of syringe **200**, asymmetrical loading of connecting section **1330** can occur if cone region **240** of syringe **200** contacts a bottom portion of shoulder portion **1350** (as in the case of shoulder **1240**, for example) during advancement of push rod **1340**. The resulting bending moment about connection section **1330** can cause failure of adapter system **1300**. To substantially reduce or eliminate asymmetrical loading, shoulder portion **1350** is preferably shaped to prevent such asymmetrical loading by, for example, being open on the top and bottom thereof (see, FIG. 10B). Removing a bottom edge of abutment shoulder **1350** where cone region **240** of syringe **200** would otherwise rest results in generally symmetrical loading about the axis of adapter system **1300** (and syringe **200**) and substantially reduces or removes lateral loads and bending moments during forward plunger advancement. Axial load applied to the end of adapter assembly **1300** is maximized while lateral load is minimized.

In addition, enforcements such as a rib **1354** can be added to carrier section **1310** to limit wall flexing by increasing the material strength as illustrated in FIG. 10B. Likewise, extension **1556** and **1558** illustrated in FIG. 12B can be formed integrally on the front portion of carrier section **1510** of adapter assembly **1500** (or adapter assembly **1300**). Cone or transition region **240** of syringe **200** preferably does not contact extensions **1556** and **1558**. When syringe **200** contacts shoulder portions **1350** (not shown in FIG. 12B) with forward force, syringe **200** can act as a wedge and force the opposing portions of shoulder **1350** apart. Forming extension **1556** and **1558** around the circumference of the front of

carrier section **1510** creates hoop forces or stresses that help prevent such deformation. Extensions **1556** and **1558** are preferably spaced sufficiently at the top portion thereof to allow ready removal of syringe **200** and any attached tubing as discussed above.

In addition to a rotating retaining member **1360** (which operates generally in a manner as described for retaining member **460** of FIGS. **4A** through **4C**) or in lieu thereof, adapter system **1300** preferably includes a biasing retaining section **1370** illustrated in FIG. **10C** and **10D**. In the embodiment of FIGS. **10C** and **10D**, retaining section **1370** includes two flexing retaining member **1372** and **1374** inset from the inside wall of carrier section **1310** to provide a pressure fit against syringe **200**, thereby securing syringe **200** in place. Retaining section **1370** assists, for example, in retaining syringe **200** within carrier section **1310** when the injector head (not shown in FIGS. **10A–D**) is rotated to a position other than horizontal when syringe **200** is placed with carriage section **1310**. Should, for example, the injector head (and thereby carrier section **1310**) be in a vertical orientation, retaining section **1370** prevents the syringe from falling out of carrier section **1310** even before retaining member **1360** can be rotated to a closed position.

In the embodiment of FIG. **10A**, retainer section **1310** is movably connected (for example, hingedly or even removably connected) to intermediate section **1320**. By, for example, rotating carrier section **1310** downward so that syringe **200** can be pulled forward without contacting the forward portion of carrier **1310**, syringe **200** can be released and removed without retracting the plunger thereof following a full or partial injection.

In the embodiment of FIG. **10A**, carrier section **1310** is hingedly attached to intermediate section **1320** via pin joints (not shown) on each side thereof.

Carrier section **1310** rotates about such pin points when closing the adapter assembly until extending members **1370** and **1372** contact abutment surfaces **1374** on intermediate section **1320**. At that point, intermediate section **1320** is generally aligned with carrier section **1310**, and carrier section **1310** is in position for shoulder **1350** to abut syringe transition region **240**. A locking ring **1380** is preferably slidably positioned on extending members **1370** and **1372**. After carrier section **1310** is rotated to a closed position, locking ring **1380** is slid rearward to abut a flange **1390** formed on the lower half of the front of intermediate section **1310** to lock carrier section **1310** in a closed position.

FIG. **11** illustrates another embodiment of an adapter system **1400** that is very similar to adapter system **1300**. However, carrier section **1410** is not hingedly attached to intermediate section **1420**. In this embodiment, push rod **1440** includes a movable section (for example, hinging or rotating section **1442**) positioned forward of intermediate section **1420**. Hinging section **1442** allows syringe **200** to be moved (rotated, in this embodiment) out of alignment with the axis of adapter system **1400** so that syringe **200** can be removed without retracting the drive member of the injector following a full or partial injection.

FIGS. **12A** and **12B** illustrate an adapter system **1500** that includes a carrier section **1510**, an intermediate section **1520** and a connector section **1530** as discussed above. Adapter system **1500** includes a cleaning or contact member such as a wiper seal **1570** and retainer ring **1580** for positioning wiper seal **1570** within adapter system **1500**. Wiper seal **1570** operates to remove unwanted contrast media (resulting, for example, from leakage and/or spillage) from push rod **1540**. In that regard, as the piston is being retracted

following an injection, wiper seal **1570** cleans/wipes any contrast media that has inadvertently adhered to push rod **1540** therefrom. Moreover, wiper seal **1570** also minimize unwanted contrast media from entering the intermediate section **1520** of the adapter system **1520**. Retainer **1580** preferably holds wiper seal **1570** in place via a pressure fit in carrier section **1510**.

As best illustrated in FIG. **12B**, push rod **1540** is preferably prevented from being removed from the rear opening of connection section **1330** by a retainer flange **1590** that abuts a flange on the rearward end of push rod **1540** (not shown in FIG. **12B**; see push rod **1640** in FIG. **13B**). The flange on the rearward end of push rod **1540** is preferably dimensioned to be slightly smaller than the inner diameter of intermediate section **1520**. The contact of contact member **1570** with push rod **1540** and the contact of the push rod flange with the inner wall of intermediate section **1520** assist in maintaining proper alignment of push rod **1540** within adapter assembly **1500**.

FIGS. **13A** and **13B** illustrate an adapter system **1600** including a carrier section **1610**, an intermediate section **1620**, a connector section **1630** and a pushrod **1640**. Adapter system **1600** includes a forward-biasing, rear abutment member **1670** that operates to bias syringe **200** completely forward in carrier section **1610** regardless of the length of syringe **200**. Abutment member **1670** is preferably slidably positioned at the rear of carrier section **1610** and is biased forward by, for example, a spring **1674** housed within intermediate section **1620**. As the operator loads a syringe into carrier section **1610**, by initially placing bottom flange **230** of syringe **200** against abutment member **1670**, spring **1674** is compressed as required to accommodate various syringe lengths. With spring **1674** compressed, syringe **200** is biased completely forward within carrier section **1610**. Abutment member **1670** also preferably includes a generally central passage **1676** formed therethrough to allow pushrod **1640** to impart force to the syringe plunger.

FIG. **14** illustrates another forward biasing abutment member **1770** suitable for use in an adapter system **1700** to bias syringe **200** completely forward within carrier section **1710**. Abutment member **1770** is slidably seated within carrier section **1710** and includes flex members **1772** that abut, for example, a forward facing surface **1712** of carrier section **1710** and bias abutment member **1770** forward. Abutment member **1770** of FIG. **14** includes three sets of inward projecting protrusions **1774** for contacting rear flange **230** of syringe **200**. Multiple sets of protrusions **1774** are provided to accommodate multiple syringe lengths. Flex members **1772** push against surface **1712** when syringe **200** is in place, thereby biasing syringe **200** in a fully forward position within carrier section **1710** regardless of syringe length.

Although the present invention has been described in detail in connection with the above examples, it is to be understood that such detail is solely for that purpose and that variations can be made by those skilled in the art without departing from the spirit of the invention except as it may be limited by the following claims.

What is claimed is:

1. An adapter for releasably attaching a syringe to an injector, wherein the syringe comprises a body, a cone region attached to a forward end of the body and a plunger slideably positioned within the body, and wherein the injector comprises a front wall, an opening formed in the front wall, and a drive member reciprocally mounted in the injector, the adapter comprising:
 - a mounting mechanism positioned at a rear of the adapter to mount the adapter in a desired position relative to the front wall of the injector; and

a syringe carrier section associated with the mounting mechanism and adapted to seat at least a portion of the syringe, the syringe carrier section defining an opening along a top length thereof to allow placement of the syringe therein from the top, a forward portion of the syringe carrier section comprising two substantially opposed, linear shoulder portions each having first and second ends, the first ends of the shoulder portions being connected by a substantially arcuate member and the second ends of the shoulder portions cooperating to define an opening therebetween, the opposed shoulder portions abutting the cone region of the syringe so that the force exerted by the syringe on the adapter during an injection is generally symmetrical about an axis of the adapter, thereby reducing any bending moment about the mounting mechanism, the syringe carrier section further comprising a rear section defining an opening therein to allow the drive member of the injector to provide forward force to the plunger.

2. The adapter of claim 1 wherein the two substantially opposed shoulder portions are positioned on a first lateral side and a second lateral side, respectively, of the syringe carrier section.

3. The adapter of claim 1 wherein the forward portion of the syringe carrier section further comprises a rib member to strengthen the syringe carrier section.

4. The adapter of claim 1, further comprising an intermediate section operably connected to and disposed between the syringe carrier section and the mounting mechanism.

5. The adapter of claim 4 wherein the syringe carrier section is removably or movably connected to the intermediate section.

6. The adapter of claim 5 wherein the syringe carrier section and the intermediate section are movably connected via pin joints.

7. The adapter of claim 5, further comprising a locking member adapted to lock the syringe carrier section in a closed position.

8. The adapter of claim 4, further comprising a push rod at least partially disposed within the intermediate section for engaging the plunger of the syringe.

9. The adapter of claim 1 wherein the syringe carrier section further comprises a retaining member for retaining the syringe within the syringe carrier section.

10. The adapter of claim 1, further comprising a biasing retaining section operably associated with the syringe carrier section, the biasing retaining section comprising at least one flexible retaining member adapted to engage the syringe body to secure the syringe within the adapter.

11. The adapter of claim 10 wherein the at least one flexible retaining member comprises two retaining members.

12. The adapter of claim 10 wherein the biasing retaining section is removably connected to the syringe carrier section.

13. The adapter of claim 1 wherein the syringe carrier section further comprises at least one flexible retaining member adapted to engage the syringe body to secure the syringe within the adapter.

14. The adapter of claim 13 wherein the at least one flexible retaining member comprises two retaining members.

15. An adapter for releasably attaching a syringe to an injector, wherein the syringe comprises a body, a cone region attached to a forward end of the body and a plunger slideably positioned within the body, and wherein the injector comprises a front wall, an opening formed in the front

wall, and a drive member reciprocally mounted in the injector, the adapter comprising:

- an intermediate section defining a passage within which a push rod can move to communicate force from the injector drive member to the plunger,
- a mounting mechanism positioned at a rear end of the intermediate section to mount the adapter in a desired position relative to the front wall of the injector; and
- a syringe carrier section hingedly connected to a front end of the intermediate section and being adapted to seat at least a portion of the syringe, the syringe carrier section defining a first opening in a rear section thereof to allow the drive member of the injector to communicate forward force to the plunger via the push rod, the syringe carrier section defining a second opening on a top thereof, a forward portion of the syringe carrier section abutting the cone region of the syringe during injection, the syringe carrier section being rotatable relative to the intermediate section to move the forward portion of the syringe carrier section out of contact with the cone region of the syringe to enable removal of the syringe from the adapter without retraction of the drive member.

16. The adapter of claim 15 wherein the forward portion of the syringe carrier section comprises two substantially opposed shoulder portions, the opposed shoulder portions abutting the cone region of the syringe so that the force exerted by the syringe on the adapter during an injection is generally symmetrical about an axis of the adapter, thereby reducing any bending moment about the mounting mechanism.

17. The adapter of claim 16 wherein the two substantially opposed shoulder portions are positioned on a first lateral side and a second lateral side, respectively, of the syringe carrier section.

18. The adapter of claim 15 wherein the forward portion of the syringe carrier section further comprises a rib member to strengthen the syringe carrier section.

19. The adapter of claim 15, further comprising a locking member adapted to lock the syringe carrier section in a closed position.

20. The adapter of claim 15 wherein the syringe carrier section further comprises a retaining member for retaining the syringe within the syringe carrier section.

21. The adapter of claim 15, further comprising a biasing retaining section operably associated with the syringe carrier section, the biasing retaining section comprising at least one flexible retaining member adapted to engage the syringe body to secure the syringe within the adapter.

22. The adapter of claim 21 wherein the at least one flexible retaining member comprises two retaining members.

23. The adapter of claim 21 wherein the biasing retaining section is removably connected to the syringe carrier section.

24. The adapter of claim 15 wherein the syringe carrier section further comprises at least one flexible retaining member adapted to engage the syringe body to secure the syringe within the adapter.

25. The adapter of claim 24 wherein the at least one flexible retaining member comprises two retaining members.

26. An adapter for releasably attaching a syringe to an injector, wherein the syringe comprises a body, a cone region attached to a forward end of the body and a plunger slideably positioned within the body, and wherein the injector comprises a front wall, an opening formed in the front

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wall, and a drive member reciprocally mounted in the injector, the adapter comprising:

a mounting mechanism positioned at a rear of the adapter to mount the adapter in a desired position relative to the front wall of the injector; and

a syringe carrier section adapted to seat at least a portion of the syringe, the syringe carrier section defining an opening on a top thereof to allow placement of the syringe therein from the top, the syringe carrier section comprising an outer wall and at least one flexing retaining member disposed inward from the outer wall, the flexing retaining member adapted to place pressure on at least one side of the syringe to retain the syringe within the syringe carrier section, the syringe carrier section further comprising an opening in a rear section thereof to allow the drive member of the injector to communicate forward force to the plunger.

27. The adapter of claim 26 wherein a forward portion of the syringe carrier section comprises two substantially opposed shoulder portions, the opposed shoulder portions abutting the cone region of the syringe so that the force exerted by the syringe on the adapter during an injection is generally symmetrical about an axis of the adapter, thereby reducing any bending moment about the mounting mechanism.

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28. The adapter of claim 27 wherein the two substantially opposed shoulder portions are positioned on a first lateral side and a second lateral side, respectively, of the syringe carrier section.

29. The adapter of claim 27 wherein the forward portion of the syringe carrier section further comprises a rib member to strengthen the syringe carrier section.

30. The adapter of claim 26, further comprising an intermediate section operably connected to and disposed between the syringe carrier section and the mounting mechanism.

31. The adapter of claim 30, further comprising a push rod at least partially disposed within the intermediate section for engaging the plunger of the syringe.

32. The adapter of claim 30, wherein the syringe carrier section is removably or movably connected to the intermediate section.

33. The adapter of claim 32, wherein the syringe carrier section and the intermediate section are movably connected via pin joints.

34. The adapter of claim 32 further comprising a locking member adapted to lock the syringe carrier section in a closed position.

35. The adapter of claim 26 wherein the at least one flexing retaining member comprises two retaining members.

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